SCHOOL SCIENCE AND MATHEMATICS

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PROFESSIONALLY MINDED TEACHERS ATTEND CONVENTIONS REGULARLY

This year's convention program of the Central Association of Science and Mathematics Teachers is planned to give a condensed summary of the recent developments in science and mathematics. Nowhere else can teachers acquire so many new ideas and methods in such a short space of time and with so little expenditure of effort. Nowhere else can teachers hope to meet personally and discuss problems with so many well-known teachers of science and mathematics.

Teachers can attend conventions if they really want to. The expenditure is not prohibitive, no more than an automobile trip on a week-end. All teachers need to do is to plan definitely to attend. They cannot attend by making excuses.

Records seem to show that less than one science teacher out of twenty-five subscribes for any journal devoted to the teaching of science. Records further show that a still smaller percentage of teachers of science and mathematics attend conventions devoted to the teaching of these subjects. Objective evidence seems to indicate that less than five per cent of our teachers are really interested in improving their teaching.

The Central Association is vitally interested in increasing the percentage of professionally minded teachers. It is doing its utmost to give you an excellent journal and an annual convention that will present to you the recent thoughts, discoveries and materials which will aid in improving your teaching.

You can do your part by joining the Association and attending its convention.

The following nationally known mathematicians, scientists,

and teachers should be added to the list of speakers given in the May issue of this journal.

GENERAL AND GROUP MEETINGS

Earl R. Hedrick, Vice-president and Provost of the University of California.

Francis O. Schmidt, Professor of Zoology, Washington University, St. Louis.

H. I. Schlesinger, Professor of Chemistry, University of Chicago.

H. C. Christofferson, President of National Council of Teachers of Mathematics, Miami University, Oxford, Ohio.

Sherman R. Wilson, Northwestern High School, Detroit, Michigan.

Mildred Fahy, President of the Department of Science Instruction, National Education Association, Peirce School, Chicago.

R. Clark Gilmore, Wright Junior College, Chicago.

O. M. Miller, Woodrow Wilson Junior College, Chicago.

Ellis C. Persing, Western Reserve University, Cleveland

Lillian Hethershaw, Drake University, Des Moines

Biology Section

A. C. Lonert, Loyola University, Chicago.

Harold G. McMullen, University High School, Madison, Wisconsin.

Physics Section

W. S. Webb, Professor of Physics, University of Kentucky, Lexington, Kentucky.

G. P. Cahoon, Department of Physics, Ohio State University, Columbus, Ohio.

Haym Kruglak, Teacher of Physics, Senior High School, Sheboygan, Wisconsin.

A. H. Gould, Teacher of Physics, Boys' Technical High School, Milwaukee, Wisconsin.

IRA C. DAVIS
President

A mathematician who is not also something of a poet will never be a complete mathematician.

—WEIERSTRASS

THE SIGNIFICANCE OF MATHEMATICS IN THE PHYSICAL SCIENCES*

By Louis Brand

Professor of Mathematics, University of Cincinnati, Cincinnati, Ohio

Mathematics has often been regarded as the perfect prototype of a pure science on account of its rigorous deductive method. It would be better, however, to rest this proud reputation upon a mode first exhibited in Euclid's *Elements:* the placing at the head of a body of doctrine the definitions and axioms upon which it is based. By omitting one or the other of these axioms, or replacing them by others, the role of each axiom in the deductive structure is placed in its proper light. Thus the characteristic feature of a body of mathematical doctrine is that it may be regarded as a function of the axioms upon which it is based. What we get out of mathematics is what we put into it. The axioms are put in; the theorems flow out—with the aid, it is true, of the laws of logic. Indeed the Aristotelian laws of logic themselves have been questioned by some mathematicians in recent years. From their point of view, a system of mathematics depends not only upon the axioms assumed, but also upon the rules by which the game of deduction is played. This extreme tolerance in mathematics will not concern us here. We shall merely consider how the structure of a geometry or an algebra depends upon the axioms upon which it is founded.

If two lines in the same plane do not intersect no matter how far they are produced, Euclid calls them *parallel.* His Postulate V in the *Elements* is equivalent to this: Through a given point just one parallel can be drawn to a given line. For nearly two thousand years geometers worried about this axiom, feeling that it was not sufficiently "self-evident," and attempted to deduce it from the other Euclidean axioms. Indeed early in the eighteenth century the Jesuit Gerolamo Saccheri wrote a book devoted to an attempt to prove Euclid's parallel axiom by *reductio ad absurdum,* and really succeeded in founding a non-Euclidean geometry—although his prejudices in favor of Euclid kept him from realizing this fact. It remained for Lobachevski, a professor at the University of Kasan, to first found a new

* Read at the Annual Meeting of the Central Association of Science and Mathematics Teachers' Cincinnati, November 26, 1937.

geometry by explicitly rejecting Euclid's parallel axiom and assuming at the start that *there are an infinite number of lines through a given point, lying in the plane of a line and not intersecting it.* The two limiting lines of this set are said to be *parallel* to the given line. Thus if we replace Euclid's one-parallel axiom, by Lobachevsky's two-parallel axiom, but retain all the other axioms that Euclid stated (plus some that he tacitly assumed) we obtain a new geometry, as consistent and as logically perfect as that of Euclid. The theorems of this geometry which do not depend on the two-parallel axiom agree with Euclid; those which do depend upon it will disagree with the corresponding Euclidean propositions. Thus for Lobachevski the sum of the angles of a triangle is always less than two right angles, the angular defect being proportional to the area. Consequently if two triangles have the same angles (and hence the same angular defect) they have the same area. In Lobachevsky's geometry there are no similar triangles of different areas; *shape, independently of size, does not exist.*

Another non-Euclidean geometry was founded by Riemann, who assumed instead of Euclid's parallel axiom, that *there are no parallels to a given line.* In this geometry the straight line is no longer open and infinite, but closed and finite. A picture of Riemann's plane geometry is given by the geometry on a sphere, allowing great circles to play the role of "straight lines," and the *two* ends of a diameter the role of a single "point." Then two "points" determine a single "straight line"; and *all* "straight lines" intersect. Moreover a "straight line" (complete great circle) is closed and of finite length. In Riemann's geometry the sum of the angles of a triangle is always greater than two right-angles, the angular excess being proportional to the area. Again there are no similar triangles of different dimensions. That Riemann's theorems are all consistent is obvious in view of its representation on a sphere.

The sphere is a surface of constant positive curvature. There are also surfaces of constant negative curvature, the simplest of which, the *pseudosphere,* is obtained by revolving the curve known as the *tractrix* about its asymptote. The geometry on the pseudosphere is precisely that of Lobachevski, so that there is no doubt of its logical consistency.

Thus as far as logical structure is concerned, the geometries of Euclid, Lobachevski and Riemann are exactly on a par. Still the question remains: Which geometry is true in actual space?

Gauss was probably the first to feel the need of verifying Euclidean geometry by direct measurement. He arranged for the accurate survey of a large triangle, with vertices on the mountains Inselsberg, Brocken, Hoher Hagen. The angle sum turned out to be two right angles within the limits of experimental error. In this test light rays played the part of straight lines, and we seem to find that this optical geometry conforms with Euclid. Actually the test was inconclusive. For in the non-Euclidean geometries the departure from an angle-sum of two right angles is proportional to the area of the triangle and our measurements may well be on too small a scale to detect the discrepancy. Since the advent of Einstein's theory of general relativity we have indeed grounds for believing that the old Greek geometry does not give an absolutely exact picture of physical space, and this in spite of Kant's assertion that we could only perceive space in the Euclidean manner. As Bertrand Russell has put it: "It appears that geometry is as empirical as geography." This is an exceptionally happy phrase; for it appears that the geography of space—the distribution of the masses immersed in it—determines the kind of geometry that holds good in any particular locality.

Various other consistent geometries have been developed; and, in short, the concept of a geometry as the outgrowth of a set of assumptions has gained a wide currency. The *utility* of a geometry depends upon its conformity with nature, upon its agreement with experiment. That precisely the same state of affairs maintains in algebra is perhaps not so widely known. Just as geometry deals with the relations between entities such as *points* and *lines*, essentially indefinable, but having the properties stated in the axioms assumed, so algebra deals with the relations between entities called *numbers*, whose basic properties are defined by the axioms of algebra. In algebra we have two fundamental operations, *addition* and *multiplication*, and the axioms of algebra state certain laws to which they conform.

In the algebra of real numbers addition and multiplication obey the *commutative* and *associative* laws:

$$a+b=b+a, \qquad ab=ba;$$
$$(a+b)+c=a+(b+c), \quad (ab)c=a(bc).$$

These laws assure us that the *order* and the *grouping* of numbers forming sums or products is immaterial. Addition and multiplication are connected by means of the *distributive law:*

$$a(b+c)=ab+ac.$$

The difference $a-b$ and quotient a/b are now defined respectively as the solutions x of the equations $b+x=a$ and $bx=a$. There is always a unique real number x which satisfies these equations for any choice of a and b, except that $b=0$ is expressly ruled out as a divisor. We note in particular that if $bx=0$ and $b\neq 0$, then $x=0$: *if the product of two real numbers is zero, at least one of them must be zero.* Thus the sum, difference, product, and quotient (divisor not zero) of any two real numbers is always another definite real number. This property is expressed by saying that the real numbers form a *field*. The linear equation $ax+b=0$ has always a real solution. But the quadratic equation $ax^2+bx+c=0$ has sometimes two real roots, sometimes no real roots. To remedy this defect of the algebra of real numbers we introduce a new kind of "number" consisting of a pair of real numbers (a,b) written in a definite order.

Let us consider briefly how we can manufacture an algebra of such numbers. First we define equality by writing $(a,b)=(c,d)$ when and only when $a=c$, $b=d$. Next we seek rules for finding the "sum" and "product" of two number pairs that will make our new algebra resemble the old algebra of reals as closely as possible. This is accomplished by defining addition and multiplication by means of the equations:

$$(a,b)+(c,d)=(a+c,b+d),$$
$$(a,b)\cdot(c,d)=(ac-bd,\ ad+bc).$$

Then is it easily shown that the commutative, associative and distributive laws hold good in our new algebra. Moreover subtraction and division are always possible and unique, provided that (0,0) is not a divisor. Finally the product of two number pairs cannot be (0,0) unless one of the factors is (0,0).

We next find that pairs of the form $(a,0)$ combine in the fashion of real numbers; for the rules above require that

$$(a,0)+(c,0)=(a+c,0),$$
$$(a,0)\cdot(c,0=(ac,0).$$

We therefore agree to identify $(a,0)$ with the real number a. *Our new numbers include the old "real" numbers.* In particular $(0,0)=0$, $(1,0)=1$; and we are pleased to find that $(1,0)\cdot(a,b)=(a,b)$.

The number (0,1) is a new number that fills a long felt need—it proves to be a square root of -1: for

$$(0,1)\cdot(0,1)=(-1,0).$$

If for the sake of brevity we write $(0,1)=i$, then

$$(0,b)=(b,0)\cdot(0,1)=bi,$$
$$(a,b)=(a,0)+(0,b)=a+bi,$$

thus making connection with the *complex numbers* $a+bi$. Complex algebra is based on the rules above; these simply amount to applying the rules of real algebra to complex numbers, with the proviso that $i^2=-1$. For example

$$(a+bi)(c+di)=ac-bd+(bc+ad)i,$$

a result in agreement with the postulated value of $(a,b)\cdot(c,d)$.

This rather long-winded introduction of complex numbers has two advantages. First, it shows that the rules of complex algebra are deliberate assumptions chosen so that the fundamental laws of real algebra still hold in the complex field. Second, the identification of $a+ib$ with the number pair (a,b) shows that there is nothing mysterious about complex numbers. There is no longer any reason to feel with Leibnitz that they are a sort of "amphibian between being and not-being." The famous "imaginary unit" i turns out to be nothing more esoteric than the pair of real numbers $(0,1)$!

The utility of complex algebra in the applied sciences, such as aeronautics and electrical engineering, is so well known that it is unnecessary to elaborate upon it here. I merely note that in the complex field we have the fundamental theorem: *Every rational integral equation has at least one root.* Indeed with a suitable convention for counting repeated roots, every such equation of the nth degree has exactly n roots. These beautiful theorems, which have no counterpart in the algebra of reals, at least justify complex algebra on the aesthetic side.

Another important algebra which deals with quadruples of real numbers (a, b, c, d) was invented by that Irish genius, Sir William Rowan Hamilton. As to the genesis of these *hypercomplex numbers* or *quaternions* Hamilton himself has written: "They started into life, or light, full grown, on the 16th of October, 1843, as I was walking with Lady Hamilton to Dublin, and came up to Brougham Bridge, which my boys have since called the Quaternion Bridge. That is to say, I then and there felt the galvanic circuit of thought close; and the sparks which fell from it were the fundamental equations between i, j, k; exactly such as I have used them ever since." Just as the *pair* (a,b) may be represented as $a\cdot 1+bi$ with the aid of *two* units $(1,0)=1$, $(0,1)=i$, *quaternions* (a, b, c, d) may be represented as

$a \cdot 1 + bi + cj + dk$ with the aid of *four* units: $(1,0,0,0) = 1$, $(0,1,0,0) = i$, $(0,0,1,0) = j$, $(0,0,0,1) = k$. If $q = (a,b,c,d)$, $q' = (a',b',c',d')$, the sum $q+q'$ is defined as

$$(a+a',b+b',c+c',d+d');$$

while their *product* qq' can be obtained by multiplying out

$$(a+bi+cj+dk)\,(a'i+b'j+c'j+d'k)$$

just as in real algebra, except that the *order* of the units must be maintained and their products found from the "multiplication table":

		1	i	j	k
	1	1	i	j	k
First	i	i	-1	k	$-j$
factor	j	j	$-k$	-1	i
	k	k	j	$-i$	-1

Here we have something really new! For since $ij = k$, $ji = -k$' we see that the commutative law of multiplication is not obeyed. But with this single exception (which entails besides two species of quotients p/q corresponding to the equations $xq = p$, $qx = p$) all the laws of algebra still hold good. Moreover the product of two quaternions can only be zero when at least one of them is zero. *The most general linear algebra* (whose "numbers" are built up by adding certain units multiplied by real numbers) *having these properties is the algebra of quaternions.*

Quaternions include the real numbers and complex numbers, which now assume the forms $(x,0,0,0)$ and $(x,y,0,0)$. Moreover they include *vectors* $(0,x,y,z)$, and indeed the algebra of vectors has been fashioned by Gibbs and Heaviside from the quaternion algebra of Hamilton. Vectors quite naturally represent rectilinear displacements in space. They are exceedingly useful in all branches of physics in which *directed quantities* (such as velocity and force) arise; and this not only in virtue of the *compactness* of vector expressions, but also by reason of their *superior transparency.*

But general quaternions also have their uses. They afford the simplest method of combining rotations in space, and for this reason come in handy in crystallography. Indeed quaternion multiplication enables one to combine directed great-circle displacements on a sphere in much the same way as rectilinear displacements (vectors) are combined. Quaternions have also

been used to advantage in Einstein's special relativity, where the time and space coordinates may be amalgamated into a quaternion *event* (t,x,y,z). But, on the whole, quaternions have not justified Hamilton's hope that they would in time dominate much of mathematical physics.

Two other algebras, however, have played a decisive role in modern physics. The *algebra of tensors*, which finds its natural field of activity in the theory of Relativity; and *matrix algebra*, which is principally responsible for the explosive development of Quantum Mechanics in the last few years. These algebras, already indispensable tools for the mathematical physicist, can only be mentioned here. We merely note that multiplication in a matrix algebra not only fails in general to be commutative $(AB \neq BA)$ but also has the novel property that AB can be zero when both A and B are not zero.

Sir Arthur Eddington in his recent (1936) book, *The Relativity Theory of Electrons and Protons*, has undertaken to evaluate by purely theoretical calculation the fundamental constants of nature. Seven such constants are usually recognized; these involve, of course, the arbitrary units of length, time and mass. But they can be combined to form four purely numerical ratios, which are utterly free from human tampering. It is Eddington's contention that the values of these four heaven-sent constants as obtained from his theory "are in full agreement with observation." If Eddington's reasoning survives the searching criticism it is bound to undergo, this book will surely become a landmark in physical theory.

In this work Eddington uses a linear algebra of "E-numbers," based on sixteen units. These units can be regarded as formed by multiplying two sets of quaternion units $1,i,j,k$ and $1,I,J,K$. Each set obeys the multiplication table given above. Furthermore the units of one set commute with the units of the other set: thus $iJ=Ji$. It is easy to show that any E-number of Eddington may be written $a+bi+cj+dk$, where a, b, c, d are *quaternions* in the units 1, I, J, K. In short, *an E-number is a quaternion whose coefficients are quaternions.* If Eddington's theory is recognized as valid, no small credit for its success must be given to the algebra of E-numbers—quaternions of quaternions. Perhaps, after all, the grandiose dreams of Hamilton may still come true!

SOME LABORATORY AIDS IN ZOOLOGY

By John P. Wessel
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The laboratory aids presented in this article were developed with the cooperation of students with advanced standing in Zoology. These aids have proved helpful in the teaching of certain phases of invertebrate and vertebrate anatomy.

Those of you who have taught the distribution of the peritoneum in the earthworm know what a difficult task this is. A knowledge of this structure in the earthworm is a real aid to an understanding of the intricate condition of the peritoneum

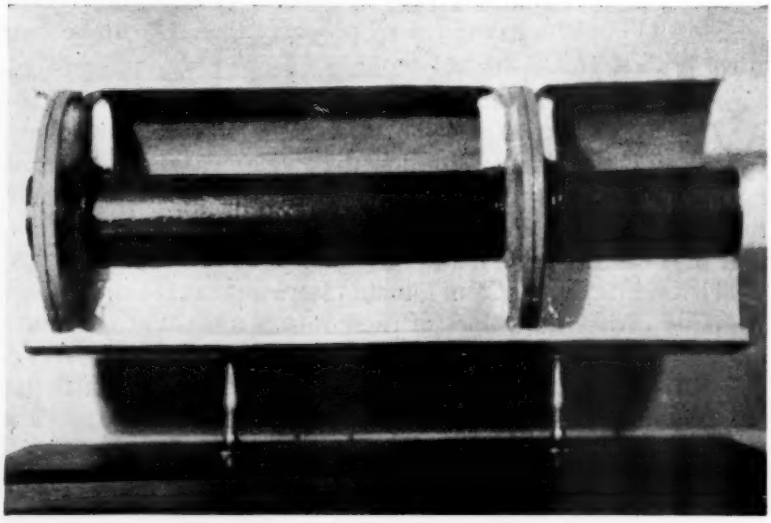


Fig. 1. Model showing distribution of peritoneum in the earthworm. Side view.

in the higher vertebrates as a result of the rotation of the liver and the tremendous increase in the length of the alimentary tract. It occurred to me that a simple model of the distribution of the peritoneum in the earthworm would be helpful to the student. With the aid of numerous micro-dissections and serial sections of earthworms we were able to construct the model shown in Figures 1 and 2. Note the rudimentary dorsal mesentery. This structure can be identified in serial sections. Other parts of the peritoneum shown in the model are parietal, visceral, ventral mesentery, and septum. Note that the rudi-

mentary dorsal mesentery, ventral mesentery, and septum are represented to show two layers of mesothelium. The model is constructed of wood and each division of the peritoneum is painted a different color.

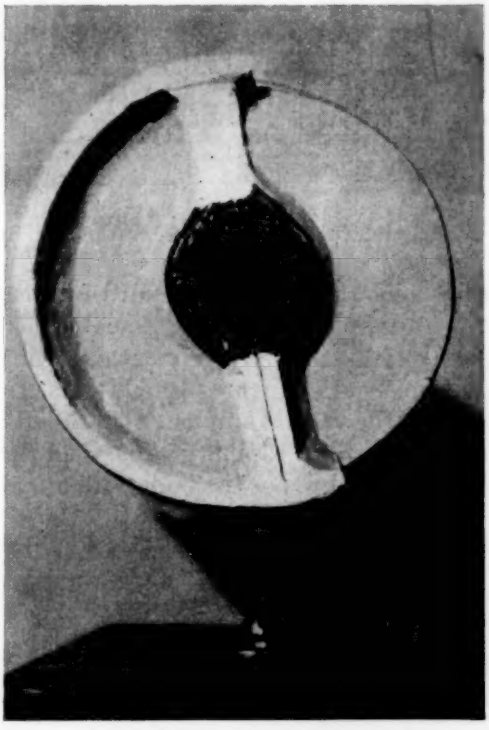


FIG. 2. Model showing distribution of peritoneum in the earthworm. End view.

Textbooks on general zoology and invertebrate zoology do not present an adequate treatment of the circulatory system of the earthworm. Students who wish to trace blood through the various structures and organs are unable to find the necessary information in the literature. It was thought that a model of the circulatory system would be helpful, and so with the aid of the literature and many serial sections we constructed one.

The hearts are made of wooden drapery rings tapered at points of attachment with the dorsal and ventral blood vessels.

All other blood vessels including capillary beds are made with wire of varying thickness. The model extends through the following regions: esophagus, ventriculus, post-ventriculus, and four and one-half metameres of the intestine.

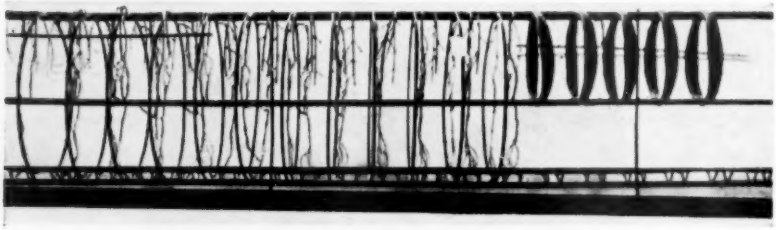


FIG. 3. Model of circulatory system of earthworm. Side view.

The following blood vessels are included in this model: Five pairs of hearts, intestino-tegumentary, dorsal, ventral, parietals, typhlosolar, afferent intestinals, efferent intestinals, gastrics, sub-neural, lateral neurals, neural connectives, right and left lateral branches of the ventral, afferent nephridials, and efferent nephridials. The intestinal capillary beds, nephridial capillary beds, and the capillary beds of the body wall are also included.

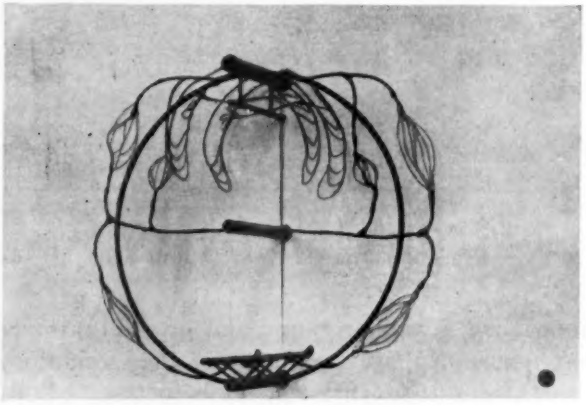


FIG. 4. Model of circulatory system of earthworm. End view of blood vessels in a single intestinal metamere.

With the aid of this model the student can work out various routes through which a drop of blood may flow, as for example, the route through which a drop of blood will travel from the intestinal bed back to the intestinal bed by way of the wall of

the nephridium in the fifth intestinal metamere. From the intestinal capillary bed it will travel to the dorsal vessel by way of either the efferent intestinal or the typhlosolar, thence forward in the dorsal vessel to one of the ten hearts. It then travels ventrally through the heart to the ventral vessel; posteriorily through the ventral vessel to one of the lateral branches in the fifth intestinal metamere; through the lateral branch to the afferent nephridial, nephridial capillary bed, efferent nephridial, parietal, and back into the dorsal; forward through the dorsal, then into one of the afferent intestinals and so back into the intestinal capillary bed. Note that a drop of blood flowing from the intestine to the nerve cord must pass through the ventral body wall.

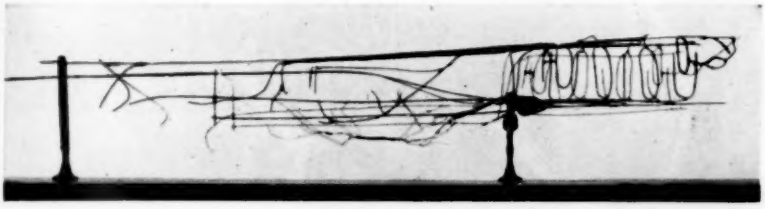


FIG. 5. Model of circulatory system in the dogfish. Side view.

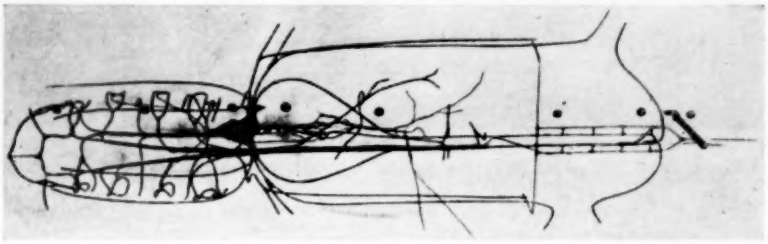


FIG. 6. Model of circulatory system in the dogfish. Top view.

Another model that has proven to be of considerable help to the student is the circulatory system in the dogfish. This model is especially useful in demonstrating the anterior and posterior cardinal systems. Other divisions of the vascular system included in this model are the hepatic portal, renal portal, systemic veins, coronary, arterial system, and heart.

At present we are constructing a model which will include the vascular and nervous systems mounted on a partial cat skeleton. In mounting the skeleton the right half of both the anterior and posterior appendicular divisions were omitted as shown in

Figure 7. The top of the calvarium was sawed off to expose the brain, which is removable. The brain and heart were made by simply making casts of the original which were filled with lead. When the model is completed the left half of the heart, pulmonary veins, and arteries will be painted in red; the right half of the heart, pulmonary arteries, and veins will be painted in blue; the capillary beds will shade off from a red to a blue. The brain, cord, and nerves will be yellow; the skeleton being bleached white.

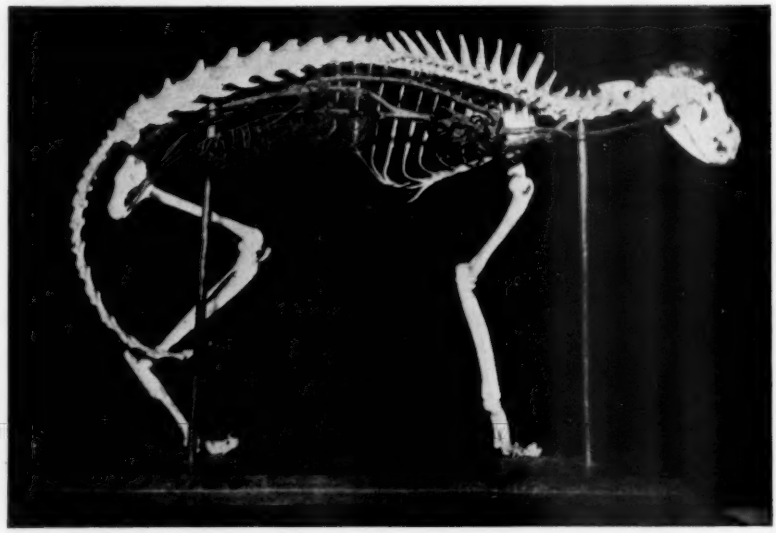


FIG. 7. Vascular and nervous systems mounted on partial cat skeleton.

DR. PAUL DOUGHTY BARTLETT OF HARVARD WINS CHEMICAL SOCIETY'S $1,000 PRIZE

The American Chemical Society's $1,000 prize to an outstanding young chemist goes this year to 30-year-old Dr. Paul Doughty Bartlett, assistant professor of chemistry at Harvard University.

Dr. Bartlett is honored for "notable progress in the borderline field between organic and physical chemistry." Born August 14, 1907, he is but 30 despite the fact that the age limit for the prize has been raised this year to 35 years.

He is the third Harvard scientist to receive the award since it was founded in 1931 by A. C. and Irving Langmuir. Funds for this year's prize, which will be presented Dr. Bartlett at the Chemical Society's Milwaukee meeting in September, were provided by Prof. James E. Kendall, head of the chemistry department at Edinburgh University, Scotland, and previously on the faculties of Columbia and New York Universities.

CONSUMER EDUCATION AND BOYLE'S LAW

By W. A. Porter

Independent School District No. 40, Chisholm, Minnesota

The average man on the street is so engrossed in this business of keeping one jump ahead of the "wolf" that he seldom has either the time or the inclination to ponder over the significance of mathematical data expressed in tabular form, this in spite of the fact that he may pay for his lack of information in terms of higher taxes or the selection and purchase of inferior products. Economists, advertisers and politicians are well aware of this human weakness and realizing the truth of the old adage that: "a picture is better than a thousand words," are making extensive use of graphs and charts in presenting their data to the public. There is, however, a danger in this, for a graph or chart is much like an optical illusion. It may infer or indicate something that is false or not present in the original data. A common way of creating this illusion is by the judicious selection of the scale units to be used in plotting the graph. Illustrations of this technique will be given later in the paper. The same effect of masking the significance of data may be accomplished by the method of expressing the figures. For example: It is commonly accepted that the national debt is now in the vicinity of thirty-six billions of dollars. This figure is so enormous that it has little meaning to John Q. Public. The common man whose pay envelope seldom contains more than thirty dollars in any one week does not, cannot think in terms of billions. He thinks only in terms of "small change." However, when we express this sum as $276 for every man, woman and child in the United States or nearly $1,000 per family, the real significance is obvious.

In these days of rapid social change and severe economic stress, the survival of our democracy depends largely on the "thinking power" of its voters. Pressure groups will offer much propaganda from which must be extracted whatever elements of truth it may contain. This can only be accomplished by an informed and enlightened citizenry.

We also hear a great deal today about "consumer education." Now it is quite evident that the student of today is the consumer of tomorrow. Therefore somewhere, somehow, during his development he must learn to interpret commercial advertising intelligently or fail to receive maximum value for the money

he spends. The real problem is: how shall these young people be prepared for the place they must take as the public of tomorrow?

I believe that physical science offers unusual opportunities for this preparation. One of the primary objectives of the teaching of science is the development of scientific thinking and its application in everyday life. However, evidence seems to point that this aim is fulfilled only when it is recognized by both the pupil and the teacher. As a possible means of developing scientific thinking and discrimination, I wish to suggest the following analysis of the data obtained in the Boyle's Law experiment in physics. The data given below were obtained by subjecting a given volume of air to various pressures and measuring the resulting volume at each pressure.

Pressure Cms. of Mercury	Volume Cubic Cent.	Pressure Times Volume
71.2 cm.	17	1210.4
75.6	16	1209.6
80.6	15	1209
86.5	14	1211
93	13	1209
100.9	12	1210.8
110	11	1210
121	10	1210
134	9	1206
151	8	1208

The students plot the data obtained in the exercise on a sheet of graph paper as in Figure 1, using the scale units indicated on the graph.

A cursory examination of the figure produced would seem to indicate that the data might be expressed in the form of a straight line with a steep negative slope. This is, of course, a false assumption but might easily be reached from a brief examination of the figure obtained when these scale units are used

(It should be noted here that the data were gathered using the apparatus available in the average secondary school laboratory. This type operates only over a very small range of pressures, and gives the results indicated. But, this is the only type of apparatus that most people ever see since few people take college physics where better apparatus is available.)

The data are again plotted on another sheet of graph paper using the scale values given in Figure 2.

Here again the shape of the figure produced would seem to indicate a straight line with a slight negative slope. Few people would recognize the data in Figure 1 as being the same as that

Figure 1

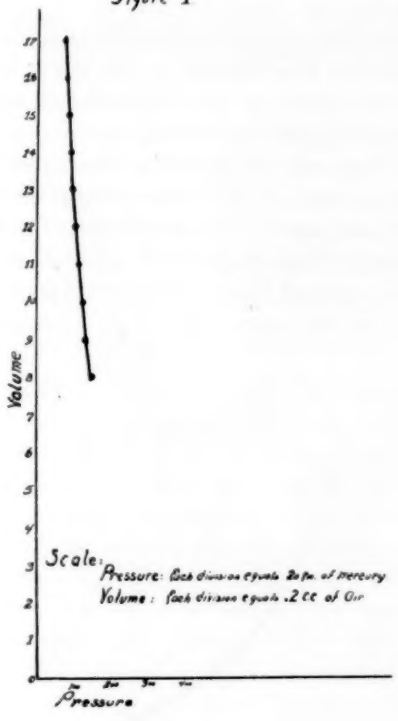
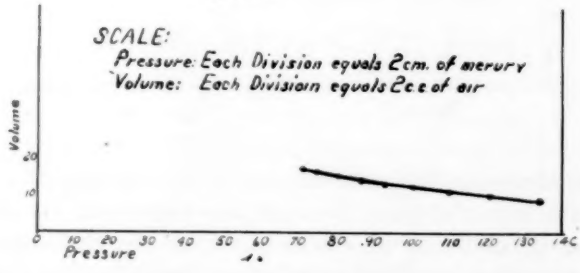


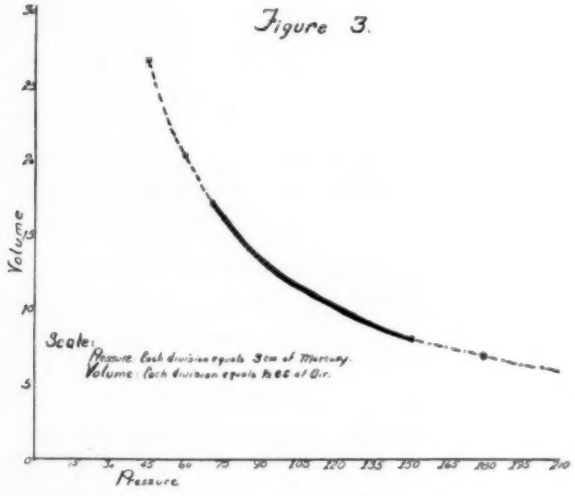
Figure 2.



in Figure 2. The facts inferred by Figure 2 are as fallacious as those indicated by Figure 1. The curvature produced in each case is so small that one who was not very familiar with the types of curves produced by the various combinations of Y

and X, would miss the significance. An obvious inference could be drawn from Figure 2, namely, with a sufficient pressure, the volume of the gas used in this exercise would become zero. This is, of course, impossible as it contradicts the Law of Conservation of Matter.

In Figure 3 the data is again plotted but in this case the scale is so chosen that the true nature of the curve is apparent. The figure is the bend point of the hyperbola that expresses the true relation between the volume of a gas and the pressure upon it. The *observed* data are indicated by the solid line. To further demonstrate the nature of the curve produced, the value of the volume for both extremes of pressure may be calculated from the observed data. These points are plotted and are shown in Figure 3 by the dotted lines. The calculated values indicate what the shape of the curve would be if complete data were obtainable.



In the above analysis the student is led to conclude that all illustrative material must be critically examined for misrepresentation or omission of essential data. The different stories told by the three methods of plotting the data that they have gathered in the laboratory makes a strong impression on the student's mind and, it is hoped, stimulates critical scientific thinking.

OPPORTUNITIES FOR SAFETY EDUCATION IN CHEMISTRY INSTRUCTION

By Ray C. Soliday

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The current wave of public interest and enthusiasm for anything concerning safety is gradually being reflected by increasing attention paid to this problem by the public schools. This paper is presented in the hope that it may stimulate thought concerning safety education in the school, and suggest means of emphasizing safety work in chemistry classes without disturbing the present curriculum.

The Function of the School

We understand that the school was developed by society to provide experiences and training which could not so well be given by the family or other social units already functioning. As our social problems become more varied and complex, our schools necessarily expand to meet the increasing needs of the pupils. At present we are under considerable pressure from society to provide additional training and experiences which our modern modes of living together seem to require. Probably the numerous curriculum conferences during the summer months indicate that school people are responding to this demand. Surely it must be agreed that if we are to justify our very existence, as well as our requirements for community support, we must be alert to the real needs of the people we serve.

The Need for Safety Education

Our present-day society meets many hazards which were non-existent a few years ago. Among the most spectacular are those caused by our high-speed transportation facilities. Other destructive machines and methods of living are so commonplace that a distinct need for safety education and accident-prevention training is being felt. Accident records provide the basis for this statement, which needs little defense or enlargement. The Press reflects public interest by devoting considerable space to reporting accident statistics. We recall predictions by the National Safety Council of probable loss of life and health during the important holiday week-ends of the past year. Sub-

sequent reports indicated that this and other agencies are able to predict rather accurately.

During the last few years a deep interest in the problem of accident-prevention has awakened in the adult public mind. It is now almost safe to say that the adult community is more vitally interested in safety education than in any other phase of our educational training. It is recognized as a real community problem, one which enters into every home, club, church, and into individual life, regardless of whether or not that particular social unit is represented in the school.

The school may be the logical and practical organization of society to provide the needed safety education. The home, of course, makes a start. Other organizations, selfishly or otherwise, are interested, but the school occupies an advantageous position with regard to organization and equipment enabling it to reach all younger members of the community. Responsibility goes hand in hand with opportunity.

Relations of Safety Education and Chemistry

Safety training and accident-prevention work involve and demand understanding of numerous fundamental laws, principles and facts of the several sciences. All of us recognize the concepts of inertia and momentum, gravity, friction, horsepower, velocity and centrifugal force as essentials of science and also as of importance in safety education. It is essential to the safety of the motorist that he develop attitudes and skills based upon an appreciation of these concepts.

Although the topics just listed probably belong within the special province of the physics department there are many others which are as definitely within the subject-matter limits of the chemistry course. An incomplete list of these is included in this paper.

A recent publication of the National Safety Council shows that carbon monoxide from automobiles in garages has annually caused deaths varying from 123 in 1924 to 609 in 1932, and declining to 352 in 1935. We are further informed that the total deaths due to "absorption of poisonous gases" in 1935 was 1,665, while in 1923 the total was 2,712. In New York City, during a five year period, there were 4,677 accidental asphyxiations of which 2,222 were from carbon monoxide. Such facts suggest that chemistry teachers may make valuable contributions to society by stressing the dangers of carbon monoxide

and methods of avoiding this poisonous gas.

Burns rank third among the principal types of accidents causing deaths. Eight per cent of all fatal accidents are burns, totalling about 8,000 per year. Over 80% of these occur in homes. Thorough training providing an understanding of the important causes of fires, construction and operation of fire extinguishers, first-aid treatment for burns, neutralization of acids and alkalies, and dangers of improper use of dry-cleaning fluids, will do much to reduce the prevalence of fires and of injuries due to burns. Furthermore, increased knowledge of fire-resistant and fire-proof materials will gradually decrease the dangers from fire-trap buildings and decorations.

An impressive list of additional topics by which the chemistry instructor may teach safety may readily be developed. It appears that the teacher might quite reasonably organize and teach a coherent unit on the chemistry of safe living. Others may teach the fundamental ideas and habits with equal success by emphasizing them as they naturally arise in the usual sequence of the chemistry text or syllabus. However, it is futile to expect that safe living will ultimately be attained unless real effort and emphasis is placed upon the attitudes and ideals which are so fundamental to such safe living. Casual mention cannot be effective to the required degree and should not be thought of as contributing to safety education.

Incomplete List of Topics in Safety Education, Related to Chemistry

1. *Fires*
   - a. Causes
     - Improper use of inflammable materials
       - in building
       - in dry cleaning
         - gasoline and naphtha
     - Spontaneous combustion
       - vegetable and animal oils
   - b. Prevention
     - use of fire-proof and fire-resistant materials
     - use of carbon tetrachloride in dry cleaning
     - protection of vegetable and animal oils used in janitor work
   - c. Fire-extinguishers
     - acid-soda type—dry soda—carbon tetrachloride type
2. *Burns and their treatment*
   - a. Butesin picrate ointment for small burns
   - b. 5% aluminum acetate solution for submerging badly burned areas
   - c. Freshly prepared tannic acid solution for atomizing upon badly burned areas
   - d. Baking soda for neutralizing acids

e. Acetic acid or vinegar for neutralizing alkalies

3. *Poisons and Poisoning*
   a. Carbon monoxide
      dangers from automobile exhausts and gas stoves
      chemical action with the blood
      first aid
         complete quiet—no exertion
         maintain body warmth
         administer oxygen if possible
   b. Poisons taken internally
      ipecac, mustard to produce vomiting
      milk—eggs—limewater
   c. Poison ivy
      ferric chloride solution

4. *Water supply and sewage disposal*
   a. Diseases borne and spread in water supplies
   b. Tests for bacterial contamination
      Petri dish cultures
      fermentation tube cultures for B. coli
      organic matter—oxygen demand, by K_2MnO_4
   c. Chemicals used in water treatment
      chlorine—ammonia—alum—charcoal

5. *First aid for wounds*
   a. Use of antiseptics
      distinction between effective and useless preparations
         plain strong hot soapsuds—1% solution compound cresol—clorox—lysol—tincture metaphen—2–5% tincture iodine

6. *Hot weather safety*
   a. Dangers of taking cold drinks while overheated
   b. Use of salt in drinking water—salt tablets

SPRINGFIELD'S "NATURE LADY" RECEIVES HONORS

Fannie A. Stebbins, recently retired from the position of Supervisor of Nature Study in the Springfield (Mass.) Public Schools has received national recognition with the same love and esteem which has always welcomed her at the threshold of the Springfield public schools. The American Association for the Advancement of Science, noted for dealing with high-brow technicians and specialists in remote fields of research, has honored Miss Stebbins by making her a Fellow of the organization. Many Springfield nature hobbyists trace their interest in the outdoors to the tireless efforts of Miss Stebbins who gave courses in Mineralogy and took them afield to study the rock stories of the Connecticut Valley. In 1910 the Museum of Natural History published her "*Insect Galls of Springfield, Massachusetts and Vicinity*," which has 32 plates that are a great help to the novice.

It is because Miss Stebbins has so much to give that she has just been elected as visiting lecturer to the new Nature Guide School of Massachusetts State College. The college is announcing in the nature school booklet two scholarships entitled the *Fannie A. Stebbins 1938 Nature Guide School Scholarships*. These scholarships are offered through the auspices of the American Nature Study Society, an affiliated organization of the triple A's or the American Association for the Advancement of Science.

"THEY CAN'T READ"

By Glenn O. Blough
Laboratory Schools, The University of Chicago

"They just can't read," explained Mr. Smith to his principal.

Mr. Smith taught seventh-grade science. His classes had become a problem. Pupils had no interest. Discipline problems began to appear. The supervised study period provided a full-time police job for Mr. Smith. The principal had just visited Mr. Smith's class. A principal-teacher conference ensued. The conclusion "They just can't read" was the result.

This is the universal cry from many of us who teach the seventh grade. What is done in face of this dilemma varies with the individual teacher. Some condone themselves by surveying the bad teaching in the sixth grade. That's always an easy way out. Others decide to make little or no use of reading material, thus limiting the class procedure to experiments and discussions. Some teachers avoid facing the difficulty by reading to the pupils rather than asking pupils to do any reading themselves. Still others, and probably this group comprises the vast majority, continue to struggle with the "dumb" pupils and all kinds of dislikes, discouragements, and disgruntles result.

Some teachers approach the problem analytically, and the result of such analysis often paves the way for progress in pupil growth. Let us now engage in such an analytical procedure and then evalate the results. Perhaps we may find valuable explanations by looking at Mr. Smith's assignments for a period of two weeks. Here they are:

Monday. "Read the next six pages in your general science text and be ready to discuss the important points." (Mr. S. began in September by assigning 12 pages—his method of overcoming difficulty having been to reduce the assignment length.)

Tuesday. "Make an outline of Chapter Eight."

Wednesday. "Look up as many references as you can that will give you information about 'Pure and Impure Air.'"

Thursday. "Choose one of the following topics and read some references concerning it. Take notes on your reading and hand your notes to me after tomorrow's class period." (List of 5 topics written on the board.)

Friday. "Free reading periods in the library."

These assignments have been gathered from an actual classroom situation. The writer has reason to believe such assignments are in many respects typical of assignments in general science in a great number of schools. Let us consider more clearly each of the assignments from the point of view of the difficulties involved as the grade seven pupil tries to satisfy their requirements.

Monday. "Read the next six pages in your general science text and be ready to discuss the important points." The pupil begins. He reads the first page and encounters these difficulties: There are words that are unfamiliar to him; some of them he can pronounce but past a verbal acquaintance they may as well be written in Egyptian hieroglyphics. There are words that are partially familiar but appear in new contexts. Example: "What is the nature of air?" Nature has meant up until now a study of birds, bees, and butterflies. The pupil reads again, "What is the nature of air?" "Oh, well, I can get along without understanding that. I'll read on." Now there is a discussion of cubic feet as compared with square feet as a means of measuring. Then he encounters a sentence containing these words: "evidence that great quantities are released from other sources which complete the cycle." Meaning what to grade 7? There are many such sentences and words and in addition there are names of chemicals and chemical apparatus which he has never seen.

Vocabulary difficulty marks only a minimum amount of the intellectual snags. Many of the concepts and principles of science are inadequately presented. They are foreign to the pupil, for he has had few experiences that help him to bring any intelligent interpretation to the printed page. The limited experiences that he has had are not recalled by the reading, because his comprehension of the text is so slight that the associations between it and the experiences described are not made. Even if the pupil understands the development of the concept as it appears in the text, he is still in a state of merely apprehending the ideas and needs further exposure before the knowledge actually becomes a part of his thinking.

A further difficulty consists of involved sentences that present new problems of understanding and make the acquiring of meanings almost impossible. Frequently the author of the text has dealt with several concepts and generalizations in the six pages assigned and has made no effort to show the reader how

these concepts are interrelated. The pupil is expected to piece together these blocks and weld them firmly into a major understanding.

Having completed the reading, the pupil, if he is above the average for grade seven, rereads the assignment and discovers: "and be ready to discuss the important points." Being a conscientious pupil, he looks back over the pages and out of the chaos tries to find just what the important points are. This involves a skill which the pupil has not needed to use for some time. His idea of the page content is hazy. His skill in selecting important points is meager. The result is that the pupil conscientiously learns the bold-faced lines on the six pages and hopes that such learning will satisfy Mr. Smith.

Let us look at difficulties involved in completing Tuesday's assignment, "Make an outline of Chapter 8." Outlining is one of the skills stressed in the elementary school. In the sixth year and in the year before that the pupils have outlined materials. Now let us see the pupil at work doing the assignment.

First he encounters the same difficulty in reading as in doing Monday's assignment. Then the pupil thinks, "Does Mr. Smith want us to use the same kind of an outline that we followed last year? I suppose he does. He didn't say so, though. Well, anyway, was it a large 'I' or a capital 'A' that is used in beginning an outline? I can't remember. I'll put the letters and numbers in later."

The pupil reads. He thinks again: "Where does an experiment go in an outline? Maybe I can just use these headings that are in black type and then write a paragraph under each one. There's a summary at the end of the chapter. Perhaps I can pick out parts of that. They should fit in." Each pupil in the class thinks through the situation to his meager satisfaction. The result is a variety of sketchy outlines as diversified as the color of a flock of pigeons.

Wednesday's assignment: "Look up as many references as you can that will give you information about 'Pure and Impure Air.'"

The pupil goes to the library to do the assignment. He thinks, "Where shall I find the material? Does every science book tell about air? Shall I look under air, or pure, or impure? I'll look in the encyclopedia." Again he finds difficulty in reading the material. He misses many of the available sources of information because there were no suggestions of places to look. Conse-

quently he again arrives at the science hour with meager preparation.

Thursday's assignment on choosing a topic, finding references, and taking notes presents the previously mentioned difficulties and the added hazard of taking notes as the material is read. Frequently the supplementary reading which the pupil must use is even more difficult than the text. There is less vocabulary control, less attempt to completely develop concepts, and the sentence construction is frequently too involved for the best reader to comprehend.

The pupil has been exposed to the idea in his reading classes in grades five and six that some of the material he reads may not be authoritative, but there are numbers of reasons why he may forget having had this experience. However, here of all places, he should be learning that there are definite criteria for determining the validity of material which he reads. He should be learning that, generally speaking, recent books on science are likely to be more authentic than old ones, that the author may be writing to tell a story rather than to relate a scientific fact, etc. Despite the fact that he has once heard of some of these criteria, his immature mind easily forgets the details and he does not apply them in this new situation.

That is only half the story. The assignment says, "Take notes on your reading." A seventh-grade boy's experience with notes may be of very slight help in the present situation! Some of the problems are: What is important to record, shall it be sentences, words, or phrases? Shall I write the notes from the book and state them in my own words? How much shall I write? Etc. Etc. All of these are problems that still remain to be solved when the feeble attempts at note-taking flutter on Mr. Smith's desk on Friday.

Friday should be fun. Mr. Smith says that I may read anything I wish. That's easy! But is it? The pupils file into the library. They are unaware of the countless possibilities in reading, for the library period has not been preceded by any suggestions from the teacher. Is a study of astronomy science? For what purposes are we reading today? How do I find magazine articles and pamphlets on any particular topic? These and countless other questions need to be settled before the library hour becomes profitable, interesting, and pleasurable.

Fundamentally the trouble has been diagnosed as "They just can't read!" Having looked at the difficulties involved in ful-

filling the requirements, is there anything amazing or shocking in this situation? In grade six the reading materials which the pupils have read are controlled for sentence structure, difficulty of concept, and vocabulary. They have been given assistance by trained teachers. True, they have done independent reading. In fact, they have done much independent reading, but not for the same purpose as that which Mr. Smith demands. The pupils are promoted from grade six to seven. A summer of three months ensues during which the average pupil reads little or nothing. The school bell rings again, and Mr. Smith meets his classes. So do the other junior high school teachers, all making new demands involving reading. The teachers console each other—another bunch of seventh-graders who can't read!

What's to be done? The key lies in the education adage, "Start with the pupils where they are and add knowledge, attitudes, skills, and appreciation to this foundation." Let us look again at the assignments and see how this attitude changes them.

Monday. If it is necessary for the pupils to read the next six pages and to discuss the important points, they need specific guidance to help them to overcome the difficulties mentioned. When such an assignment is given for the first time, it might well be carried out during the class time under the supervision of the teacher. Such a lesson will yield valuable information regarding the ability of the class to read and interpret the pages of the book. The way in which subsequent assignments are given will depend on the outcome of this class exercise. It may be necessary at the beginning of the seventh grade to do much reading in the classroom. The gathering of the important points may need at first to be a class exercise. Difficult words in the text may need to be explained to the pupils before they begin to read outside assignments, and they will, no doubt, need much help in deciding which are the important points. A series of study questions may need to be developed by the teacher to help the pupils learn to focus on essential meanings. Such procedures as these may not be necessary for all classes or for most classes during the whole year. But until the reading skills and techniques that are more or less peculiar to the subject are mastered, such help will be necessary.

Tuesday's lesson necessitates helping the pupils also. A discussion of such questions as these on the day that such an assignment is first made will be very helpful: What do you

already know about making an outline? What kinds of things should be included in an outline? What is the purpose of making an outline? What form of outline shall we choose for our science work? Suppose you look at Chapter 8, and let us make an outline of those pages together. Read the first page and be prepared to offer a suggestion for starting. Keep in mind the purpose of our outline and the form which we are going to use.

With this sort of background the pupils can gradually become more independent in their working and thinking. As a result there should be less waste of time and effort in preparation of the assignment and better results should be obtained.

Wednesday's assignment again needs to be prefaced by a discussion that will serve to review such questions as these: What are the possible sources of information on the topic? Under what headings will you expect to find information that will be helpful? How shall we decide if our information is accurate? How can you tell if a book contains the information which you want?

After a discussion of such questions the pupil should have background for proceeding with his assignment in a more intelligent way.

Thursday's lesson involves the technique of note-taking, which is a difficult one for grade seven even when the material is easily read. Again a method of note-taking should be worked out as a class exercise so that pupils will have a clearer understanding of the assignment.

The free reading period needs planning on the part of the teacher if best results are to be obtained. Pupils need to be shown the possible sources at hand and need to be able to survey the possibilities sufficiently so that the library period can be of real help in promoting a wider interest and a profitable type of recreatory reading.

Because the ability to comprehend the printed page is so necessary to adequate learning in general science, the teacher of science cannot escape being a teacher of reading. The pupil, especially during his early experience in grade seven, will need much help if he is to make a satisfactory adjustment to his new educational environment. Probably there is no other one factor that needs more attention than reading if we are to more effectively bridge the gap between elementary school and junior high school.

OILS, FATS AND WAXES IN ANCIENT TIMES

By Eugene W. Blank

Colgate-Palmolive-Peet Co., Jersey City, New Jersey

Civilizations, not unlike living organisms, mature, grow old, decline and die but of their life and experience some record is usually to be found. The works of Dioscorides and the justly famous *Historia Naturalis* of the elder Pliny give a vivid and meticulous description of the empirical scientific knowledge amassed by the ancients. The writings of Theophrastus, an able pupil of Aristotle, of Herodotus and of a score or more of lesser luminaries serve to amplify and clarify acquaintance with the chemical arts as they existed at the dawn of civilization.

The ancient peoples were acquainted with a wide variety of oils and fats and with petroleum, pitch, turpentine and beeswax. They utilized oils for edible purposes, as lubricants, illuminants, as medicine, as a material for the preparation of soap and as an extraction solvent for essential oils which were highly prized and extensively used in the manufacture of perfume. In the course of their various chemical operations with the oils and fats the ancients invented and utilized the water bath, the oil press and the filter. Pliny in addition describes a simplified form of distillation for the production of turpentine.

The Egyptians were well versed in the chemical arts and stand out prominently among the earlier civilizations as having consciously applied their practical knowledge of chemical processes to the problems of everyday life. The Egyptians were familiar at a very early date with various metals and alloys, dyes, glass and pharmaceutical preparations of various sorts. The high priests were custodians of the chemical art, preserving its secrets most sedulously. In many cases the laboratories were adjuncts to the temples. In Greece, on the contrary, the various chemical arts were practiced by the despised artisans. From Egypt the manufacture of chemical products spread to the Phoenicians and Jews, to the Greeks and afterwards to the Romans. In China and India some knowledge of the practical applications of chemistry existed long before the rise of the western civilizations. However, it was not until the intervention of the Arabs in the early Middle Ages that the crude empiricalism of the ancient peoples attained the dignity of a science.

The olive tree was cultivated extensively by the ancients and highly esteemed for the oil which it furnished by the simple

operation of pressing. The oil obtained from the olive by hand pressure appears to have been known at the earliest period of which we have any historical record.

In the first century B.C., a Roman architect, by name Vitruvius, wrote the work through which his fame has survived the centuries.

Speaking of the plans for a farmhouse Vitruvius says, "Let the pressing room, also, be next to the kitchen; for in this situation it will be easy to deal with the fruit of the olive. Adjoining it should be the wine room with its windows lighted from the north. In a room with windows on any other quarter so that the sun can heat it, the heat will get into the wine and make it weak."

"The oil room must be situated so as to get its light from the south and from warm quarters; for oil ought not to be chilled, but should be kept thin by gentle heat. In dimensions, oil rooms should be built to accommodate the crop and the proper number of jars, each of which, holding about one hundred and twenty gallons, must take up a space four feet in diameter. The pressing room, itself, if the pressure is exerted by means of levers and a beam, and not worked by turning screws, should be not less than forty feet long, which will give the lever man a convenient amount of space. It should be not less than sixteen feet wide, which will give the men who are at work plenty of free space to do the turning conveniently. If two presses are required in the place, allow twenty-four feet for the width."

Pliny speaks of olive oil being pressed from the ripe olive by placing the latter between warm plates of tin or iron. The oil was subsequently protected from rancidity by saturation with salt. Olive oil had numerous uses, amongst others it was used to extract the volatile oils from such materials as rose petals by placing the latter in a glass jar of the olive oil and exposing the whole to the sun. Among the flowers treated in this manner Pliny lists the lily, saffron, marjoram, narcissus, the pink, calamus and others.

The Greeks and Romans were also familiar with rice oil. Pliny speaks of a tree whose fruit is " . . . like a cluster of grapes." The oil was obtained by pressure or by boiling the grain with water and then decanting the oil which rose to the surface. It was used chiefly as an illuminant and in medicine as a purgative.

Among other oils Pliny writes of almond oil, of sesame oil,

grape oil, walnut oil, palm oil, black radish seed oil and nettle seed oil.

Palm oil, because of its ease of production, was known to a great many of the early races. It was usually and most simply obtained by leaving the fruit to decompose in holes in the ground and skimming off the fat as it rose to the surface of the mass.

The Egyptians raised flax and it is quite probable that they extracted linseed oil from the seeds. The oil was no doubt used as an edible and cooking oil for which purpose it is still used to some extent by the poorer classes of Egypt.

The ancients knew of a great many essential oils but very few of them were pure since, in general, their essential oils were solutions of essences in fatty oils obtained by macerating aromatic plants in olive oil. In this manner the oils of myrtle, of rose, iris, cardamon, cinnamon, marjoram, of narcissus and of lily were prepared. All these oils were used in perfumery and the preparation of perfumes constituted a renowned industry. Many of these oils were colored with vermilion or orcanet to enhance their appearance.

Oil of citron and of laurel were the only pure oils known to the ancients and this was due to the fact that it was possible to obtain them without the use of an extraction solvent.

The use of perfumes seems to have originated in Persia though there is some doubt about the matter. The Romans regarded perfumes as one of the honest pleasures of life. The word perfume (*per*, through, *fumum*, smoke) indicates clearly that it was first obtained by burning aromatic gums and woods. Criton, Hippocrates, and other eminent doctors of the times classed perfumes among medicines and prescribed them for many diseases, particularly those of a nervous kind.

Theophrastus, in his famous treatise, *Enquiry into Plants*, writes extensively of the nature, causes and sources of odors and gives detailed descriptions of the preparation of numerous perfumes and unguents. The odor-bearing materials were frequently used in dried and powdered form and many different substances were often mixed in the same powder. Theophrastus goes so far as to say that the powders are better the more ingredients they contain.

Compound perfumes were made by mixing a variety of aromatic roots and placing them in a closed box. At intervals the one with the strongest odor was removed so that the smell of

no one ingredient would overpower the others.

In India perfumed oils were prepared by placing gingelly oil seeds in alternate layers with fresh flowers in a covered vessel. The latter were renewed several times, after which the seeds were pressed, and the oil then obtained was found to have acquired the smell of the flowers.

In connection with the preparation of unguents, Theophrastus gives us the first description known of the water bath. "But in all cases, the cooking whether to produce the astringent quality or to impart the proper odor, is done in vessels standing in water and not in contact with the fire, the reason being that the heating must be gentle, and there would be considerable waste if these were in actual contact with the flame, and further the perfume would smell of burning."

At all of the festivals held by the Egyptians in honor of their numerous deities, perfumes played an important part. The richer class of Egyptians covered their skin with costly ointments, the poorer classes used as a substitute, castor oil, which Egypt produced in abundance.

Saffron was one of the perfumes most in favor with the Romans. The Romans used unguents with a different perfume for each part of the body. Besides this, their baths, their clothes, their beds, the walls of their houses and even their military flags were impregnated with sweet odors. Some carried this taste so far as to rub their horses and dogs with scented ointments.

The odor of violets was a favorite with the Greeks and various blends of mint and thyme were also quite popular.

The recent and highly specialized development of the paraffin and hydrocarbon industries would lead one to believe that petroleum products are modern materials but the fire on the Hebrew altar, fed by the Jewish priests, was a counterpart of our modern petroleum and was called "Naphthar" or "Nephi," a Hebrew word meaning purification.

Dioscorides writing of naphtha says that it is found in Babylon and that it is white in color, though sometimes found black. Writing of the remarkable properties possessed by this material Dioscorides points out that fire attacks it with great energy, so that it even seizes upon it from a far distance.

Dioscorides also speaks of bitumen and describes its occurrence in Phoenicia, Sidon, Babylon and Zacynthos.

Herodotus describes the use of hot bitumen as a cement in

setting the bricks in the walls of Babylon. The source of the bitumen was the Is, a small stream flowing into the Euphrates, eight days' journey from Babylon.

Pliny describes "Maltha" as a product like naphtha that quickly takes fire and burns even upon water so that it can only be extinguished by the use of earth. He goes on to say that the uses of bitumen are for medicines, for coating the insides of vessels of copper or brass against the action of fire, for staining bronze statues, as a cement for bricks, for varnishing iron and the heads of nails to prevent their rusting.

The first illuminants used by man were probably animal fats. The subsequent use of vegetable oils was an important advance in civilization because it depended upon the development of vessels for holding the oil and wicks. Locally obtainable oils and fats tended to be pressed into use and so to this day in many countries fats and fatty oils are still used to the exclusion of imported mineral oils. Thus butter fat serves today as a burning oil in the Hindu temples of Southern India (where cow *ghi* only may be used) and in the lamaseries of Tibet. Up to the middle of the last century olive oil and rape oil were the illuminants in use throughout Europe. At present linseed oil and castor oil are popular burning oils in India; as is tung oil in Japan.

Carvings and paintings in the darkest Egyptian tombs show no traces of smoke. On this evidence olive oil, rendered smokeless by salt, may have been used as an illuminant. Herodotus describes the lamps used in Egypt at the time of his visit as " . . . flat saucers filled with a mixture of oil and salt on top of which the wick floats."

Numerous fats were known in bygone days. Pliny gives a comprehensive list. The most valuable fat was obtained from the hog. Next in order came goosefat which was melted in hot water, filtered through linen and allowed to cool and harden. Dioscorides says fats are prevented from becoming rancid by being covered with honey.

Among crude peoples the saponification of fats by means of alkalies with the object of preparing soap is of more or less usual occurrence. The natives of West Central Africa, especially the Fanti race, are accustomed to wash with soap prepared by mixing crude palm oil and water with the ashes of banana and plantain skins.

In the old sacred records the word "soap" is mentioned twice, once in the book of Jeremiah and once in Malachi. However,

the allusion is probably to the juice of a plant used by the dyers of woolens. The Greeks did not know soap since Homer, who gives a minute account of their domestic life and customs, does not mention the word.

The first authentic mention of soap is made by Pliny, who speaks of a remedy for tumors made by mixing oil and ashes.

According to Pliny soap was first introduced into Rome from Germany, having been discovered by the Gauls, who used the product obtained by mixing goats' tallow and beech ash for giving a bright hue to the hair. The aqueous extract of ashes was probably strengthened (rendered caustic) by the addition of lime. A distinction was drawn between soft and hard soaps, according as potash or soda was used in the preparation, the soda being obtained from the ashes of shore plants in Gaul.

The process has not yet completely died out and is still used on a small scale in those localities where a cheap and plentiful supply of wood ashes is obtainable. Thus this type of soap is still sold by the Kabyles on the markets in the interior of Algiers.

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SOUNDPROOF TABLES

Students who patronize the Commons cafeteria of Iowa State College are dining now in a din that is only 48% as bad as it used to be.

A 52% reduction in the volume of noise has been achieved by attaching cornstalk acoustical board to the undersides of tables, chairs and other articles of furniture. The board was developed by Dr. O. R. Sweeney and was placed in its unusual location because putting it on the walls and ceilings would have altered the decorative scheme of the dining hall.

ON THE STUDY OF MATHEMATICS[1]

By Frank W. Bubb
Washington University, St. Louis, Missouri

I wish to make a few common sense remarks about mathematics. I address these remarks to those of you who can and ought to give to children certain sound ideas about mathematics. You mothers, fathers, and teachers may, incidentally, learn important things about mathematics yourself, if you will meet the child upon his own ground.

Let us suppose that you are so fortunate as to possess a three year old youngster of your own or so unfortunate as to have a neighbor who does. We shall agree, for brevity, to designate your little darling or the neighbor's small nuisance, as the case may be, by the name of Bill. It is to be understood that little Bill is a realist.

At an early stage in his career, you will probably ask Bill the question, "What is two and two?" You may expect him to reply that two and two make four. But Bill, being still a realist, will make no such meaningless assertion. On the contrary, he will counter by demanding, "Two and two what?" This does not mean that Bill is stupid; it means that he is much more clever than even you give him credit for being. If you are sensible enough to say two apples and two more apples, Bill will reply, "Four apples." If you say two pennies and two pennies, he will reply, "Four pennies."

The abstract proposition that two and two make four has, in itself alone, no meaning; and this is perfectly apparent to Bill because he has not yet learned the dangerous art of making abstractions. Unless both the twos appearing in the statement refer to something real, the statement has no meaning. However we become weary of always saying so carefully that two spoons and two more spoons make four spoons, two bullets and two bullets make four bullets, two objects of any kind and two more objects make four objects, that we end by stripping off the adjectives two, call them abstract nouns, and say for shortness that two and two make four. One calls this assertion an abstract proposition, and the operations which put meaning into the assertion constitute the process of abstraction. Mathematics is concerned primarily with such abstractions.

[1] Radio address over KSD, Saint Louis, February 2, 1938.

Upon a child's first exposure to arithmetic, extreme care should be taken to see that he is not only shown clearly the abstractions being made, but he should be taught to make them himself. Little Bill already has the realistic attitude, and this can be so easily developed into the critical attitude which is the very essence of science and mathematics. Bill should be taught, and this is perhaps the most important lesson in logic he will ever learn in this pig-iron world, that he must distinguish between a valid abstraction and a spurious one: the valid refers to something real, the spurious does not.

It is not easy in the beginning to mislead a child; his natural realism protects him from fools and deceivers. But if he be exposed long enough, he will eventually succumb and accept that fatal compulsion which seems to weigh upon the minds of most persons and under which they are impelled to believe in the reality of the subject and predicate of every grammatically correct sentence—especially if the sentence be uttered in perfect diction by high authority. In other words, the child can be forced into that class of persons known to predatory salesmen and politicians as the suckers.

The child can in many ways be taught some of the absurdities of spurious abstraction—for example, by reading to him Lewis Carroll's book *Alice in Wonderland* which is, beneath its fantastic surface, an excellent exercise book on logic. I am thinking here particularly of that precious bit of fantasy concerning the Cheshire Cat. This cat had a notable grin, and at the moment, was following Alice about, disappearing and reappearing in bewildering fashion. Upon his last disappearance, the cat slowly dematerialized, beginning at the tail and vanishing toward the head. Finally the head vanished leaving nothing but the grin. And then the grin slowly dissolved into nothing. This transcendental operation whereby Lewis Carroll detached the grin from the Cheshire Cat is an amusing parody upon the procedure of abstraction in mathematics—and I might add the procedure in a sales or in a political build-up.

One finds numerous abstractions which have no more validity than this cat's detachable grin. One does not have to listen to politicians or to read books on economics to find spurious abstractions, one can find them even in our most respectable sciences.

Little Bill should, I think, be deliberately taught how to abandon mental contact with the realities which his words

designate; but he should also be taught that if he does this, or if he uses words which do not refer to realities, he talks nonsense. Unless he understands how to play this game himself, he will be the soup-bone for every wolf who attacks him with sales talk or political oratory.

At the foundation of every mathematical system there lies a set of familiar elements which are left undefined because they are familiar. In arithmetic these elements are apples, pennies, bullets, spoons, in short, the things which are counted, added, and so on. To simplify the mathematics, these elements are not always mentioned—they are represented by symbols. Thus the elements which concern arithmetic and, of course, geometry are familiar to all of us whether we be adept in these sciences or not. In other branches of mathematics the elements which constitute the field of operations may not be so familiar. In fact, one rather quickly reaches the stage where the elements are left undefined. This does not mean that the mathematician does not know what these elements are. It means that they are obtained by a process of abstraction, that they are intelligible only in terms of certain previous mathematics.

In arithmetic one learns the four fundamental operations of addition, multiplication, subtraction, and division, and as one's experience grows, certain laws concerning these operations become apparent. It is an easy matter to illustrate one of these laws, perhaps the most fundamental law of nature, by calling upon our young hero Bill again.

Bill lives across the street from a school.[2] As he plays in his own yard, being too young to attend school, he observes the children run out into the school yard at recess where they play a game which seems to be called eenie-meenie-minee-mo, etc. Perhaps he does not get the idea of the game, but he learns how to play one of his own. As the first child emerges from the building, Bill calls him eenie, the second one meenie, the third minee, and so on, ending at the word toe, say. He plays this game day after day and finally observes that he always ends upon the word toe regardless of the order in which the children come out. In other words, small Bill discovers that the number of objects in a given set does not depend upon the order in which they may be counted. Upon this proposition hangs all the laws and prophets in arithmetic as well as in many other fields.

[2] I am indebted to Dr. G. N. Lewis for this little parable.

Matters of this kind can be taught to a child in his own home, where he gets his first ideas of counting and arithmetic. Any mother can demonstrate the above law to her child in a short time by having him count, as a game, a set of objects in different orders. It is also an easy matter to show the fundamental laws of order and association for addition and multiplication.

The most critical period in a child's mathematical education comes when he studies algebra. This science is a generalization of arithmetic. The operations of arithmetic are assumed to apply generally. For example, whereas in arithmetic one only subtracts a smaller number from a larger, in algebra one may subtract any number from any other. This requires us to extend the number system to include negative numbers. Other operations require us to extend the number system still further until the concept of number becomes so general that any operation of algebra or combination of operations lead, when applied to these generalized or complex numbers, only to numbers of this same kind. Such a complete system of numbers is called a field.

The student of algebra must be made familiar both with the number field and with the operations of algebra. This must be done carefully and completely or the student never finds out what it is all about. A sympathetic teacher always realizes that his students become confused periodically. He watches for the symptoms as a doctor watches a disease, and prescribes individually for his students. This is why we need teachers—books can't do this.

Having developed algebra and its field, one can go on to speculate on what may happen if one alters the field, the operations, or the laws of combination. Thus, one may define other operations, one may deny the validity of certain laws and substitute other laws therefor, or one may deal with a new field. For example, one can add and multiply vectors, tensors, matrices, and other entities. And so, abstraction upon abstraction, one can build up mathematical systems.

It remains the first business of both teacher and student to see that these entities are clearly understood before such technical matters as their manipulation is studied seriously. This ought to be obvious enough, but lack of proper attention to it causes most of the difficulties in mathematics. Until a new concept is firmly fixed with respect to the student's previous experience, he is like unto a traveller in a strange land. Unless he learns the new landmarks, is it surprising that he becomes lost

in attempting even the shorter journeys by himself?

We can learn another great lesson of mathematics from little Bill. The lesson is: ***never overlook the obvious.*** Once upon a time two great mathematicians had an argument. One of them, an Englishman named Sir Isaac Newton, claimed—and here I shall have to make a free translation of his Latin—that the "dignity" of a body in motion should be measured by multiplying the mass of the body by its velocity. The other, a German named Leibniz, maintained that the "dignity" of a moving body should be measured by half its mass times the square of its velocity. These quantities are called respectively the momentum and kinetic energy of the body, and they certainly sound more scientific than the vague word "dignity." The argument waxed acrimonious, in fact undignified, but it came to no conclusion during their life time. Let us see how little Bill would resolve a similar question.

Suppose that you are in a magnanimous mood or that you are trying to square yourself. You ask Bill what will he have, ice cream or candy. Bill, with no hesitation, replies, "Both." And you who would have said ice cream alone, or you who would have said candy only, may if you doubt it, ask him yourself. Bill always sees the obvious. And this gives us the answer to the Newton-Leibniz question: the modern engineer and physicist uses both momentum and kinetic energy to measure the "dignity" of a moving body.

Perhaps it is asking too much to expect those of us who have become republicans, democrats, pacificists, vitalists, materialists, in short, who have over-learned the process of abstraction, always to see the obvious. Many mathematicians, physicists, and other scientists have stumbled squarely upon simple things of the greatest importance and have failed to grasp them. This seems to be due to the fact that these men confuse the meaning of mathematical symbols just as the layman confuses the meanings of words.

Before closing, I wish to refute a statement usually attributed to Bertrand Russell. The allegation is that mathematicians are persons who, among others, do not know what they are talking about but who are unique in that they do not care. This statement is a gross libel, and in fact, is a misquotation of what Russell really said.[3] Mathematicians are among the few who carefully train themselves in the art of making abstractions.

[3] See "Mathematics and Metaphysicians" by Bertrand Russell, *The International Magazine*, 1901.

They frequently know what they are talking about, and others can find out too if they hold fast to the realism of little Bill.

The techniques of mathematics are no more difficult than other techniques, for example, those of music. The big thing is to appreciate the very real problems of mathematics. The techniques are the by-products of the great problems. And the difficulty which most sensible persons have with mathematics is due to their having to learn the techniques before learning some of the things that mathematics is designed to do. There is about as much sense in this way of teaching mathematics as there is in forcing a child to learn the technique of some musical instrument without ever taking him to hear real music so that he may learn what is expected of him.

I frequently hear an intelligent man or woman declare that they were unable to make any sense of mathematics. I always take this statement to heart because I regard it as an indictment of my own profession of teaching. The admission is usually made in an unnecessarily humble spirit, because in many cases it could be, with more justice, put in the form, "My teacher of mathematics was so dull and so ignorant either of his subject or of the art of teaching it that he was unable to give me any adequate idea of what this great science really is."

My sympathies are entirely with little Bill in his attitude toward mathematics. When we meet him on his own ground, we have no difficulty in teaching him. And finally when we who are mathematicians abandon little Bill's point of view, as most of us occasionally do, we cease to be mathematicians.

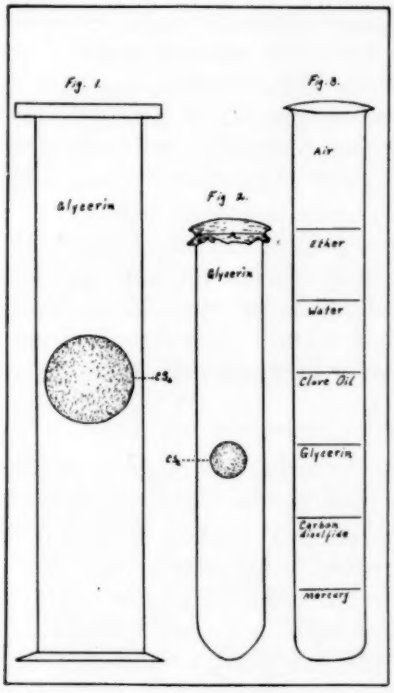
MATHEMATICS POSTER CONTEST

The Women's Mathematics Club of Chicago and Vicinity sponsored a poster contest held the week of May 14 to 23 in the Club Women's Bureau at Mandel Brothers, Chicago. Posters contributed by the mathematics departments in cooperation with the art and other interested departments of the participating schools showed the practical applications and the value of mathematics to daily life, the correlation of mathematics with other subjects in the curriculum, and many other phases of mathematics and its uses. Prizes and awards were given for the best individual posters and for the best school group. The contest was in direct charge of Miss Ida D. Fogelson of the Bowen High School, Chicago. The judges were: Elizabeth W. Robertson, Director of Art, Chicago Public Schools; Noble J. Puffer, Superintendent of Cook County Schools; F. C. Brown, Curator, Department of Physics, Museum of Science and Industry; Daniel Catton Rich, Associate Curator of Painting, The Art Institute of Chicago; Otto Geffken, President, Business Men's Art Club.

SURFACE TENSION AND RELATIVE DENSITIES

By Howard H. Hillemann
Custer Co. High School, Miles City, Montana

A number of different combinations appear to be in use for the purpose of illustrating the effect of surface tension on the shape of a liquid when a small portion of it is temporarily suspended in a medium that will prevent any great inequality in pressure from any one point. If any liquid, insoluble in water



and heavier than it per unit volume, is released drop by drop from a pipette into a tall cylinder of water, the drops on their descent will obviously round themselves into apparently perfect spheres. Oil of wintergreen or carbon disulfide dropped into water will act in that manner. However, the drops after reaching the bottom become somewhat flattened and the perfect sphericity is lost.

A method of getting a drop suspended for a long time, with only a very slow descent, appeared to be of value for closer

examination by a large number of students. A suitable combination for this purpose is that illustrated in Figure 1, in which a drop of carbon disulfide is suspended in pure glycerin. The large laboratory cylinder is first very nearly filled with the highly viscous glycerin, and then a long drawn-out pipette equipped with a large bulb, after being filled with carbon disulfide, is inserted some distance below the level of the glycerin. The carbon disulfide is slowly and steadily forced out without interruption into the glycerin, in which a perfect ball of carbon disulfide of relatively large dimensions appears. The larger the sphere, the more fascinating to the student. The downward motion of the carbon disulfide drop is very slow indeed.

A smaller and more permanent form of the above is that illustrated in Figure 2. A fair-sized test tube is used, and after the drop is inserted into the glycerin, a sufficient amount of the glycerin is added to fill the tube completely. A rubber dam of two thicknesses is then stretched over the top and flush with the glycerin, excluding all air bubbles. The dam is fastened securely against the lip of the tube by a rubber band. In this case, when the drop reaches the bottom, the tube can be inverted back and forth for repeated observations. If any air bubbles are included, they tend to break up the carbon disulfide drop into a number of smaller drops as the air bubbles brush past the drop.

In the March, 1936 issue of SCHOOL SCIENCE AND MATHEMATICS, a short item by the writer appeared, accompanied by a diagram illustrating a method of setting up a permanent form tube for demonstrating relative densities.

This idea of relative weights can be further emphasized by a simple set-up indicated in Figure 3. In this there are six different liquids, the one sharply delimited from its neighbors because of insolubility, and each in its corresponding position according to decreasing weight from bottom to top.

This tube has one obvious disadvantage, that is, it cannot be inverted back and forth, for in so doing, those liquids which are mutually soluble will mix and there will then remain only three layers. The ether, clove oil and carbon disulfide will form one layer, the water and glycerin a second, and the mercury a third. Some care must be exercised in setting up the tube. Each liquid should be added gently on top of the one immediately below it by means of a long pipette or glass tube.

RECENT TRENDS IN CONSERVATION EDUCATION*

By Richard Lee Weaver
Cornell University, Ithaca, New York

We are launched on a fight for conservation education. Just as nature study, health, vocational and music education have challenged our educators for a recognized place in our school curricula, so does this new challenger, conservation education present its qualifications for recognition.

However, not all of these newer additions to our curricula have had equally strong ammunition with which to fight. Certainly health and vocational education answered certain economic needs. Music and nature education relied more on needs that were admitted to be based on appreciation and not economics.

In fact you are all familiar with some of the ruses used to place nature study and music in our curricula by legislation. They have not been accepted everywhere and have not been generally augmented by federal funds, as has the vocational program. Due to federal legislation, via the Smith-Hughes Act, vocational training was placed on a fairly permanent basis. Health and physical education, although not so strongly supported, have a firm footing. Some of you may know of instances where nature study could be taught only as it pertained to health education. But what of nature study and its newer ally conservation education? Nature study was one of the first subjects to be wiped out when expenditures had to be cut. It will take years to regain the ground lost by such retrenchment. Can conservation education expect this same treatment in the years that will follow?

As you perhaps have realized, I am making certain assumptions. First, that conservationists are trying to put conservation education into all of our curricula, and secondly, that conservation education may receive federal support. They are more than assumptions, they are facts as I will show you. But can this be justified and what claim has conservation education to a place in our curricula?

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* Presented at the meeting of the American Nature Study Society at Indianapolis, December 27, 1937.

If some of you have been following these trends throughout the United States as have Dr. Palmer, your past President, and a committee of graduate students at Cornell, you will realize that both of these assumptions, or facts, are within the realm of possibility. Some conservationists are trying to legislate conservation education into our curricula generally. They are going beyond some of our more progressive schools that have included conservation courses in their programs for 20 or 30 years and are trying to make it mandatory in all our schools.

The fact that some of our states have reacted favorably to such pressure and that a bill seeking federal support was recently presented to a legislative committee of Congress, certainly speaks well for the justification of support. Just how loudly it speaks remains to be seen. It is not my purpose here to attempt to justify conservation's claim to such support. In such a group as this I feel that would be entirely unnecessary. Some of you may feel that it could be better taught in conjunction with all subjects, and in this you may be justified.

However, I would like to point out that due to the nature of the claims that can be made for conservation education, it has a better case on which to gain support than some of the already adopted programs had. Indeed it may have a stronger case than nature study itself, unless you agree with some of us that conservation education is nothing more than the basic study and the appreciation of nature with an emphasis placed on the preservation of that same nature. Perhaps, therefore, acceptance of conservation education will help the cause of nature education. Certainly nature education can be of great assistance to good conservation education.

As time goes on and our natural resources continue to become more and more depleted, more attention will be directed toward this field, with attendant support. The time for action may be right now. There are many resources that cannot wait if they are to be saved at all. Legislative action is all that can save some of them now. But as in all cases, in order to secure proper legislation and have it adhered to, education must precede it.

Witness the recovery of the sealing industry of the northwest. Effective means of control and use has followed a thorough study of the conditions by the government. Our salmon and whaling industry is doomed if it is not checked with proper means of control. Perhaps if more people were aware of this disaster, national and international cooperation could be

quickly obtained. Legislation could save it.

Just as in this case, where some of the whalers realized that their industry demands whales and have encouraged control and have adhered to the legislation of their respective countries, so here in the United States have certain states acted separately in adopting conservation programs. They have not waited nor needed federal support and guidance. But what can conservationists of Washington and Oregon salmon interests, or any group, do alone to protect and save our salmon industry of today? How can pressure be brought to bear, for instance, on our Bureau of Fisheries to investigate possible effects of such projects before giving permission to such a doubtful enterprise, as that of placing power dams across the best salmon streams of the country? Should our federal government impose such projects on any section of the country without a majority of the interests involved being in agreement? In many cases they were not even consulted.

Witness on the other hand, though, what effective education has done so far in restricting the building of a canal across Florida. The National Resources Board and others have investigated the possible effects, found them to be destructive, and have stalemated the politicians so far in their attempts to railroad it through. Education cannot always stop political "pork-barreling" but it can limit it decisively.

Bird protection means very little to many people until some ruffians rob or destroy a thrasher's nest that they have been watching in their hedge. Gunners think very little of conservation until they can no longer find turkeys or ducks in their native haunts. This makes it difficult to obtain an equal distribution of emphasis even in the field of conservation itself.

Game birds and mammals are receiving many times the consideration that non-game species and flowers are at the present, especially in our so-called conservation departments. Why? The gunners are demanding birds to shoot, their money is used to support important parts of the programs. Should naturalists and other laymen demand birds? Should our nearly extinct species such as the ivory-billed woodpeckers and kites receive support? Should non-gunners demand that some emphasis be placed on non-game species? If they should, how can this be brought about? Should more of us buy hunting licenses so that an additional amount of money will be available for conservation of more than game species? No! In very few states

are conservation departments ready to have us do this. Michigan, with its well-organized division of education under the Department of Conservation, is one of the few groups to educate rather than specialize in propagandizing. New York and Pennsylvania should be able to do much more for conservation generally with their unbelievably large receipts each year. But what can be done to receive a fairer distribution of support? Certainly placing the money from hunting licenses into the general fund and having the programs supported from this fund of general taxes would take away some of the feeling that sportsmen's money is paying for the work of our conservation departments. In fact, in New York State, sportsmen provide less than one-half the support of the Conservation Department! They are encouraged to think they give more however, by the officials of the Department. Here again we must look to education. General education must be used to counteract effectively the propaganda and the pressure of certain of these groups. Just as in nature study, where strong programs are built up over a long period of time, mostly as the result of one or more strong leaders, so has the conservation in the schools been developed. But we need more leaders for both programs.

Florida and Wisconsin stand as leaders in this new movement to enforce the teaching of conservation in all the schools of their states. Their programs have been under way two or three years now, and results are forthcoming. Recent publications and plans from Wisconsin encourage the idea that a program legislated into being can be a good thing. However, Wisconsin may be far advanced in the education of their layman. This would warrant such legislation. Miss Partridge in Florida did an unusually effective piece of work paving the way for their law. Tangible results are not here as noticeable as in Wisconsin.

A month ago a letter informed us that Oklahoma has joined these two states and has passed a similar law. Other states are considering it. Vermont and Massachusetts have discussed it. What is going to be the result of this legislation? It depends largely on the strength and durability of the support that the bills had. If the leaders have prepared their teachers properly and the need is felt, success is possible. If legislators have acted politically rather than thoughtfully and provision has not been made to train teachers first, then success may not be forthcoming. In fact, too many failures may cause the usual reaction of discouraging others before they start.

The federal government has not remained free from this fight to legislate conservation into our schools. At our last regular session of Congress, a bill sponsored by Senator Copeland of New York was brought before a committee but was denied consideration. This was to be expected as Senator Copeland was acting outside the influence of the administration, even though President Roosevelt is probably more conservation-minded than any previous President. Why did it fail? Perhaps it was entirely political, but perhaps more than that. We may not be ready for it. Some of our legislators certainly need some education when it comes to matters of conservation. Others may only need to be more conservative.

At any rate, conservation education federally supported lost in its first rounds. Training of the backers may not have been thorough enough, or their interest strong enough. But a return encounter can be expected. Let us hope that the fight be placed effectively before the nation's legislators. Two defeats might prove fatal, a third chance may not arrive. Real conservationists should be brought in to help the politicians, especially "those-in-favor." The very origin of the bill may be attacked in that certain practices for obtaining federal support were not adhered to or felt important.

This federal legislation is not of the same nature as the state legislation mentioned previously. It does not, indeed, cannot, enforce school measures, and therefore cannot make the teaching of any subject mandatory. It can make federal funds available for the states that are ready to meet them fifty-fifty in placing the program into their schools, just as was done in the Smith-Hughes act previously mentioned for vocational education.

If the federal and state governments are going ahead with this program to place conservation in the schools it is up to us to prepare our teachers now so that they may be ready to administer such programs. This means strengthening our teacher-training so that teachers prepared today have a thorough background of basic science as well as an understanding and appreciation of the basic principles of conservation.

Cornell University has been engaged in training undergraduates and graduates in conservation for a number of years, but more recently has entered the field of research in conservation education.

Funds were made available last year to the Graduate School

for an intensive study of conservation education. Dr. Palmer, the director of the project, has been an ardent conservationist for many years. His interest was recognized, and these funds have made it possible for him to emphasize this work for the last two years. Fellowships were offered so that graduates interested in this work could assist him in the project.

It was only logical, following customary methods of research, to organize and conduct a survey of the present knowledge and emphasis on the subject throughout the country. This phase of the work required all of the time of the four graduate students selected last year to participate in the project. It is being continued this year by two of last year's committee and an additional new member. Four divisions were recognized: private agencies, federal agencies, educational institutions, and state agencies exclusive of the educational divisions.

The survey has required the contacting of thousands of people and hundreds of agencies. Letters, questionnaires, personal interviews, inspection trips, conferences, and the reviewing of publications have been used effectively.

The second phase of the work, that of aiding other workers in the field has proceeded as rapidly as possible. Members of our committee have been requested to help prepare projects for certain groups, give talks to groups of teachers, write articles and editorials on conservation, and give advice on courses of study. Schools and organizations were requested to apply for assistance. Opportunities have presented themselves in our fieldwork to address groups and to make suggestions concerning particular programs. One of the members recently returned from a three weeks field trip through New England contacting members of game departments, state school boards, federal government projects, and private organizations. He talked to college classes en route, and explained the nature of our project. This was in addition to the main purpose of the trip, that of learning what contribution they were making to the field of conservation education. An attempt will be made to cover most of the eastern section of the United States. A trip by one of the members is contemplated this spring, in which the middle western states and perhaps some southern ones will be included.*

The third and perhaps the most constructive part of the work

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* This trip covering twenty states has since been made. Thirty-six states have been visited personally by members of the committee during this survey.

remains, and must follow after the survey has been completed. This is the application of these findings to our present day needs. Outstanding projects in the country that illustrate good techniques, good content, proper philosophies, or unusual results, should be pointed out to others. Fallacies of certain programs, such as labeling things conservation that are not, should likewise be pointed out. Certain of the findings can undoubtedly be used by states contemplating conservation education programs, in the formation of their teacher-training courses and the elementary courses of study. Private and public organizations certainly can profit by an outside evaluation of their programs.

It is refreshing that an opportunity exists to make this study free of obligation to any commercial interests. Examples in conservation education are known where this has not been so. In some cases these interests have biased the findings. They should not in this study.

We plan to incorporate as much of our findings as possible in articles of interest and publish them in magazines that will reach the groups most affected. Some editors have already requested copy dealing with certain phases of the research.

We feel that Cornell University is and should continue to be in a position to give service to teachers, administrators and laymen in this field of conservation education. We are trying to do our share of the training of teachers and leaders to enter this expanding field. We hope that the work will be able to continue and perhaps stimulate others to increase their emphasis on conservation education.

NEW ATOM SMASHER BEING CONSTRUCTED AT UNIVERSITY OF MINNESOTA

A new atom smasher is under construction at the University of Minnesota which should speed atomic particle bullets at atoms with energies of 4,000,000 electron-volts, it was disclosed at the meeting of the American Physical Society.

The new apparatus, now under construction, was described in the report of Prof. John T. Tate and Drs. L. H. Rumbaugh and J. H. Williams.

The equipment, when complete, will look like a steel "blimp" 36 feet long. This blimp forms the roof of a cylindrical, underground observation chamber. The control room—in which the scientists will sit while operating the atom smasher—is also underground and protected by six feet of earth and concrete. Winding tunnels will connect with the nearby physics laboratory. The apparatus will obtain its energy by building up electrostatic charges. The steel blimp is necessary since the device will work under a pressure of 100 pounds to the square inch.

A PERIODIC ARRANGEMENT OF THE ELEMENTS TO MEET MODERN CHEMISTRY NEEDS

By K. Gordon Irwin

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There is a need for re-designing the Periodic charts now in use so as to make them fit modern theory and the present-day needs of the chemistry classroom. This is necessary if for no other reason than that of saving our chemistry texts from becoming mere encyclopedias of rapidly accumulating facts. That there are even more important reasons will be referred to in the discussion that follows.

The discovery of Mendeleeff, upon which all classification arrangements have been based, appeared in 1869 in essentially the following form of statement: "The properties of the elements are periodic functions of their atomic weights. This relates not merely to the chemical characteristics of the elements but also to their physical properties." After the work of Moseley in the years just before the World War the idea of atomic numbers was substituted for atomic weights, but otherwise the statement of Mendeleeff has remained unchanged.

To recognize in a more or less general way the truth of the statement is one thing, to understand the exact nature of the periodicities that exist is a far different matter. The periodicity of melting point does not follow the same pattern as the periodicity of density, nor the periodicity of density the same pattern as the periodicity of valence, nor valence the same pattern as that of chemical activity. The same, in general, is true of other properties. Mendeleeff placed the elements in a table arrangement so that he might present the periodicity of valence. For this property the table form was satisfactory because the valence pattern was highly symmetrical and the table did not distort the relations to be brought out. For the periodicity presentation of the other properties, chemical and physical, the rigid table has proved to be very poorly adapted.

Modern theory and modern experimental work has but corroborated the accuracy of Mendeleeff's discovery. It has, however, shown a need for re-interpreting the classification plan represented by Mendeleeff's table. The entire system of the elements is now recognized as being an entirely continuous one that starts with hydrogen, the simplest and lightest of all the atoms, and ends with uranium, the most complex and

heaviest. Each atom fits perfectly into this continuous plan. Unfortunately no table form can show a steadily changing and unbroken arrangement, as all tables, of necessity, are broken up into segments.

That other forms can be given to the classification plan has

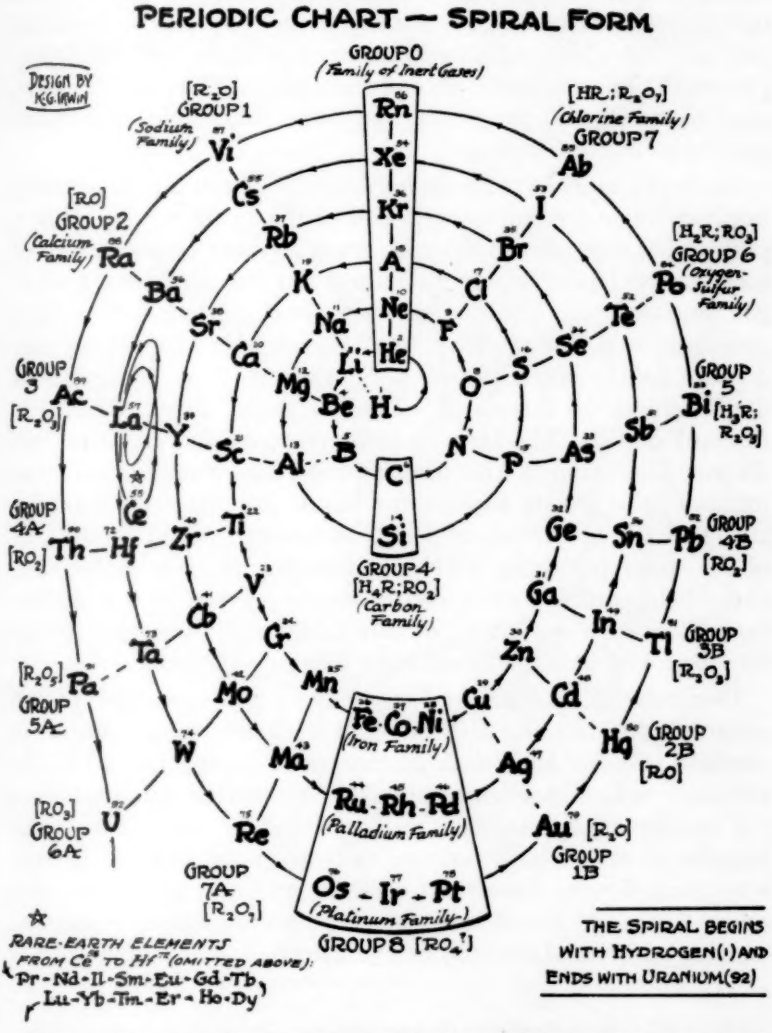

FIG. 1. The Periodic Chart in Spiral Form. This form has many advantages for the chemistry teacher. It fits completely into the modern theory of the atom, unique positions in the chart being taken by the elements without valence, those sharing electrons as is the case with Carbon and Silicon, and those of Group 8 where electron reorganization occurs.

long been recognized. One of the most fruitful of the comparatively recent classifications likens the system of atoms to the great nebular spirals of astronomy, giving to the atom-plan a spiral form. A chart using such an arrangement fits the needs of modern theory, retains all of the family features of the table forms and, what is probably most important, permits a visual indication of the periodicity pattern of any physical or chemical property for which sufficient data are available. The main purpose of the present article is to present such a chart and to show, applied to it, the periodicity patterns of certain important properties of the elements.[1]

As shown in its initial form in Figure 1 the spiral arrangement begins with hydrogen(1), each coil of the spiral representing a period that ends at the top with some member of the family of inert gases. The first period contains but two elements, hydrogen and helium. Then come two short periods with eight elements each, followed by two long periods of eighteen elements. As the sixth period gets under way an independent double-spiral of rare-earth elements stops, for a time, the forward motion. The last, or incomplete, period contains but six members, ending with uranium(92). The reason behind the failure of the system to continue lies in the extremely complex structure of the atom that has been reached at this point. All of the atoms beginning with polonium(84) are so unstable that they disintegrate spontaneously, some having but a highly temporary existence. It is possible that equally unstable atoms may be found at some future time beyond uranium.

Using the spiral chart and applying to it the methods of the geographer in running lines of equal elevation upon a map it is possible to show the relations that exist among the atoms in reference to some particular property. For such a representation the expression "periodicity pattern" will be used. From the large number of characteristics that might be charted in this way the following have been selected: valence, to amplify the presentation of Mendeleeff; density; metallurgical relations; melting point; and activity of the metals.

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[1] Both I. W. D. Hackh in his *Chemical Dictionary* (1929) and J. D. Clark in the *Journal of Chemical Education*, November, 1933, have suggested spiral forms for the classification of the elements. The form devised by the writer and used in the present article has certain features common to the others, but differs in a major way from both in the handling of the rare-earth elements and from Clark in the location of hydrogen.

Valence

The periodicity pattern of valence (Fig. 2) shows that there are two well defined areas, A′ and A″, where the advance from one element to the next in the different periods is associated

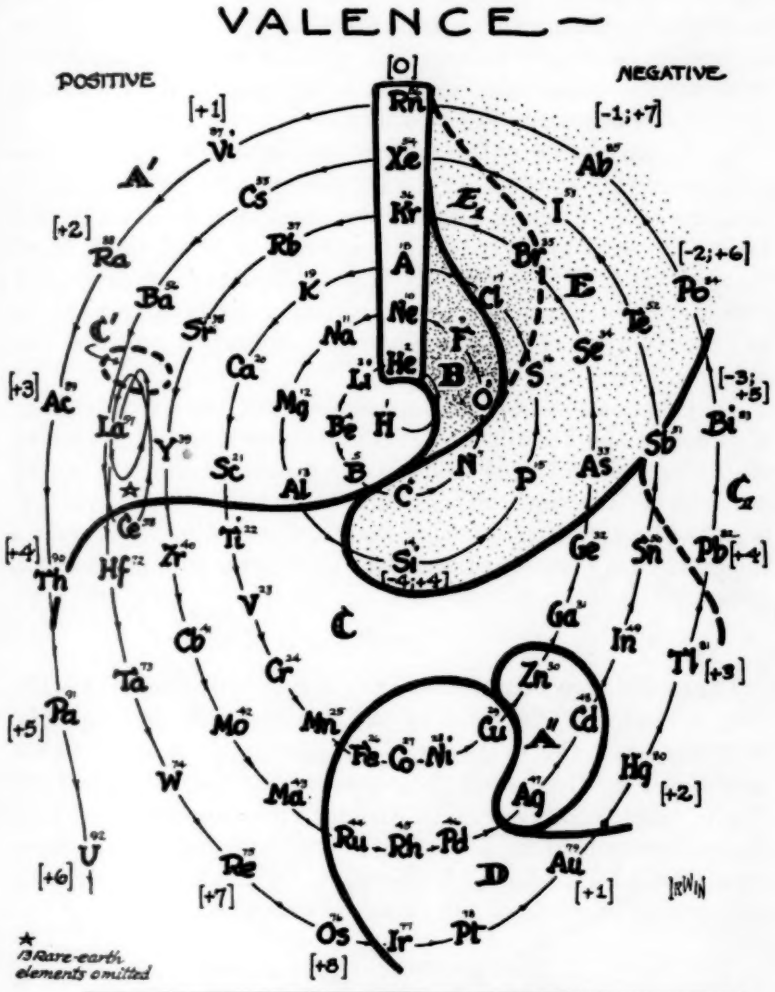

Fig. 2. Periodicity Pattern of Valence. Definite areas are indicated where the advance in the valence value is plan-following.

with a change in valence that increases at a regular rate, each element having but a single valence. In the adjoining area, C, the regular increase in valence continues but represents the maximum valence only, the elements showing two or more different valences. In the area at the bottom of the chart, D, more than a single valence is possible for each element but the maximum no longer follows any plan of advance; for these elements the usual valences must be learned by the chemistry student, for the chart offers no help.

In the upper center we find, in the keystone position, the inert gases that have no combining power and a valence, therefore, of zero. Immediately to the right are fluorine(9) and oxygen(8) with a negative valence only. Beyond these is an area, E, in which the elements show a valence toward hydrogen that increases regularly downward and a different maximum valence toward oxygen that decreases regularly downward, the sum of the two being eight.

An examination of the chart shows that the exact valence of almost a third of the elements is thus specifically given. For all but ten of the entire number the maximum valence can be determined. Whether the maximum valence is the usual valence is not indicated definitely; for such limited areas as E_1 and C_1 the maximum is rarely reached, for C′ it is the minimum which is equally unusual.

Density

The periodicity pattern of density is relatively simple (Fig. 3). The advance in the value of the density from hydrogen(1), helium(2) and the other gases—at the upper center—to osmium(76), heaviest of all the elements—at the bottom of the chart—is remarkably regular. Although densities have not been definitely reported for a number of the elements, such as those numbered 43, 75, 84, 85, 87, 89 and 91, the chart permits a close estimate to be made of the expected densities.

Metallurgical Relations

Metallurgically the pattern of Figure 4 is divided into two well-segregated portions, one of metals, the other of non-metals. Among the metals there are equally characteristic lines of separation. Beginning at the upper left we have in group A a number of light, easily-corroded, chemically active metals without structural value. Below them in group C are the

numerous rare-earth and related elements, closely alike physically and chemically. They are comparatively rare, comparatively active and comparatively weak, a combination of properties that has left them with few industrial or metallurgical

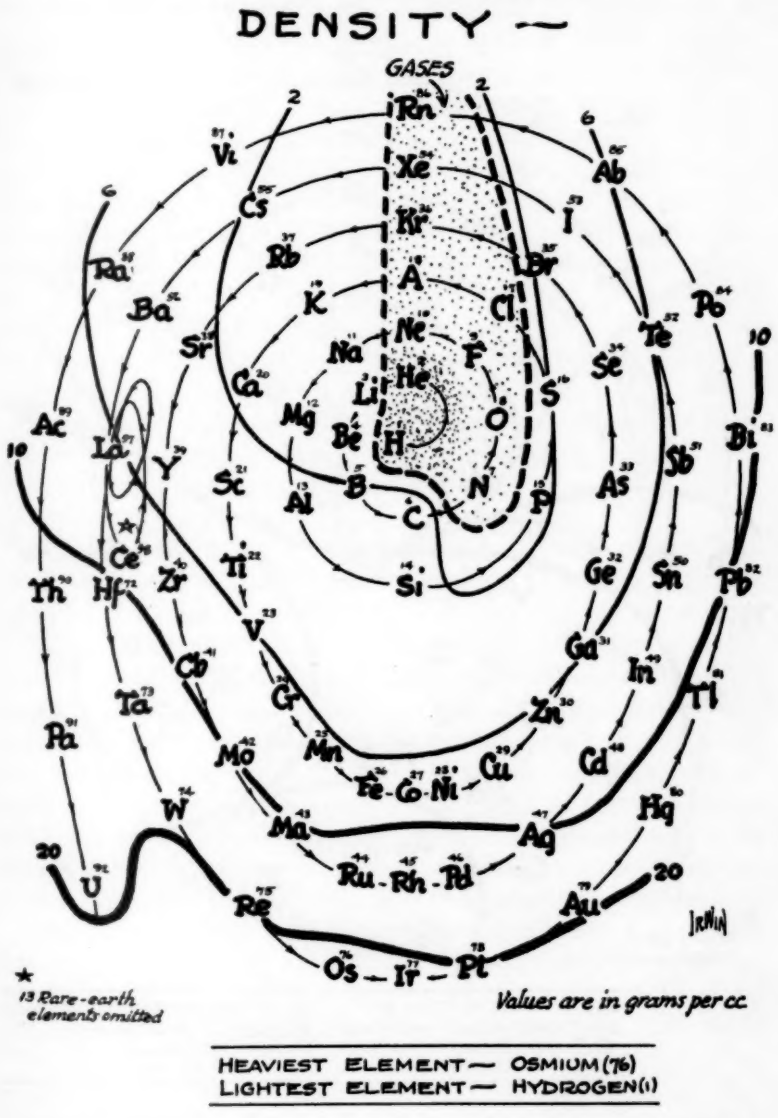

FIG. 3. Periodicity Pattern of Density. The advance is remarkably uniform, moving outward and downward from hydrogen.

applications. At the bottom of the chart in group F are the "noble metals," heavy, very inactive, most of them soft and malleable, highly resistant to corrosion or acid action. In this

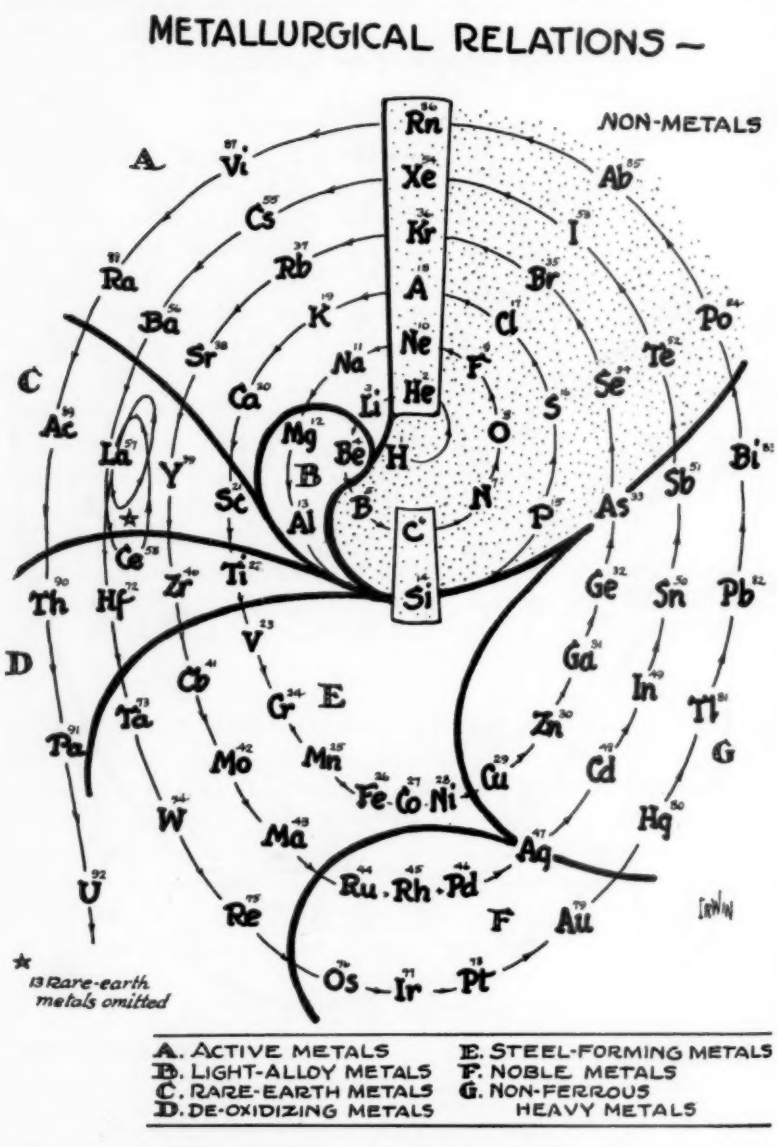

FIG. 4. Periodicity Pattern of Metallurgical Relationships. Not only are the non-metals separated from the metals, but the metals also form well-defined groups.

group are gold(79) and platinum(78). Too weak and expensive for structural purposes they are used for plating other metals, for jewelry, coinage, and other special work.

The industrial metals are included in the remaining groups. Group E are the steel-formers. Alloyed with iron the other metals of the group give to steel such additional advantages as greater toughness, hardness, resistance to shock, ability to withstand corrosion, or elasticity. Seven of the group are commonly used for such purposes: vanadium(23), chromium(24), manganese(25), cobalt(27), nickel(28), molybdenum(42), tantalum(73), and tungsten(74). Of the other three, columbium(41) is being tried out; the remaining two are much too rare for industrial exploitation. The particular alloy-steel which has received wide attention in recent years is stainless steel, which has a beautiful silvery finish, extreme hardness, strength and resistance to corrosion. This steel contains 18% of chromium and 8% of nickel. Hundreds of other alloy-steels are possible, many are in wide use.

Compounds of the steel-forming metals with carbon give such intensely hard substances as the widely used tungsten and molybdenum carbides, exceeded in hardness only by boron-carbide and the diamond.

Group D, adjoining the steel-formers, includes metals that are often added to the melt in the making of steel. Their chief purpose is to remove undesirable substances, such as oxygen.

The light-alloy metals, group B, consisting of magnesium(12), aluminum(13) and beryllium(4), have come rapidly to the forefront in recent years. Aluminum and its alloys are strong competitors of the steels for streamlined trains, of copper in the electrical transmission field, of tin in the wrapping of candy. Magnesium is a third lighter than aluminum and is competing with aluminum where lightness is important, as in the aviation industries. Beryllium, by far the most expensive of the three, has had its possibilities only partially determined.

The remaining group, G, includes all of the non-ferrous heavy metals (as they are referred to in industry), among the most familiar of which are copper(29), zinc(30), tin(50), lead (82), antimony(51), bismuth(83) and mercury(80). Silver(47) borders on the noble metals, arsenic(33) on the non-metals. The uses of these metals in unalloyed form are numerous; in such alloys as brass, bronze, nickel-silver, solder, babbitt, type-metal, bell-metal and dozens more, their use are often even greater.

With but minor modifications the same periodicity pattern can be used to point out other metallurgical features of the metals. The noble metals are found in nature largely in native

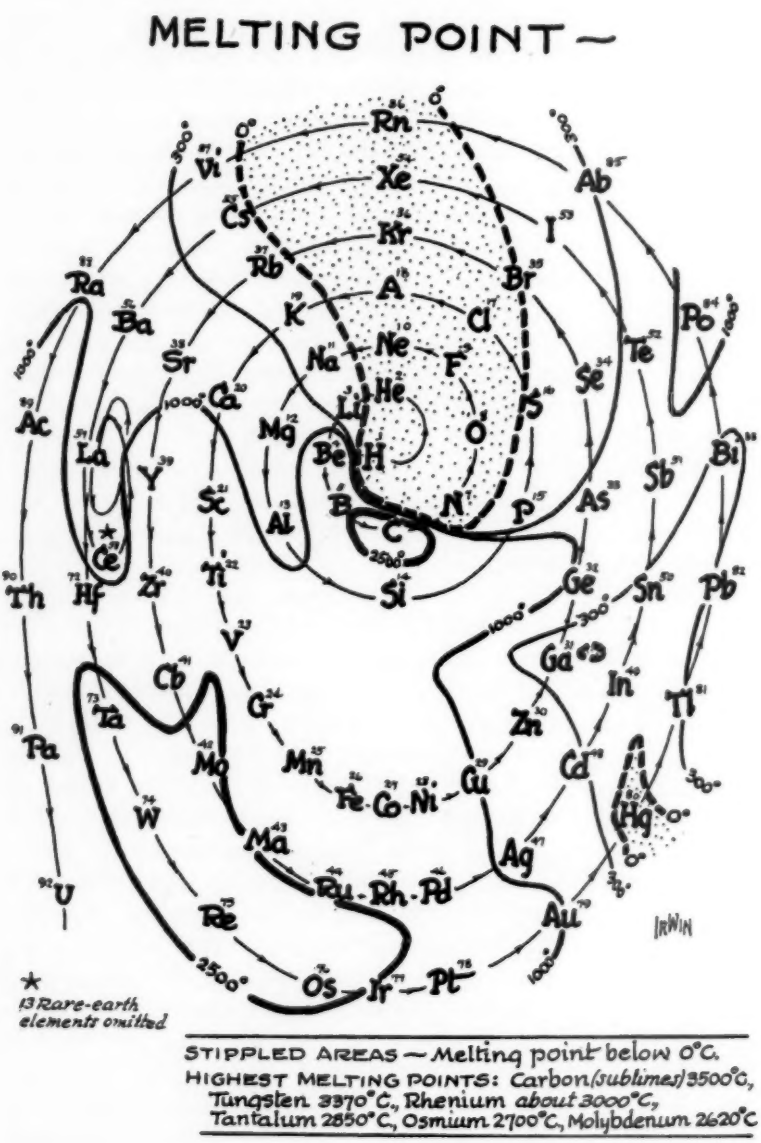

FIG. 5. Periodicity Pattern of Melting Points. Slightly over a third of the elements have a melting point in excess of 1000° C.

form, and nearly always as natural alloys with other members of their own group. The non-ferrous heavy metals are largely mined as sulfides. Such sulfides in the process of metallurgy are roasted to oxides, which in turn are reduced with carbon to obtain the metal. The steel-formers are largely mined as simple or complex oxides. Unless the presence of carbon is undesirable the oxides are reduced with carbon as in the blast furnace. For the remaining groups of metals (A, B, C and D) the reduction of the metallic compound is accomplished by electricity, as is the case with the production of aluminum from bauxite, and of magnesium from fused magnesium chloride.

The curving line that crosses the chart horizontally has, therefore, a wider significance than that of merely separating two groups of metals, or metals from non-metals. It also separates to almost as sharp a degree those metals that can be secured from their ores by the use of carbon in the form of coke from those that require electricity.

Melting Point

The melting point periodicity pattern, Figure 5, has its area divided almost equally between elements whose melting points exceed 1000°C. and those which melt below that temperature. Two areas appear in which the melting point is over 2500°C. One of these includes carbon(6) only; the other tasks in molybdenum(42), tantalum(73), tungsten(74), rhenium(75), and osmium(76), and narrowly misses iridium(77), ruthenium(44), and masurium(43).

Two other points are strikingly brought out by the chart. A low melting point area appears at the right, centering around mercury(80) and gallium(31). The other point to be noticed is the relatively high melting point of beryllium(4) as compared with magnesium and aluminum. This is of importance industrially.

Activity of the Metals

Figure 6 shows the periodicity pattern of chemical activity of the metals as related to their action with water, hydrochloric acid, nitric acid, and aqua regia. The metals that react with water to produce hydrogen and a metallic hydroxide are in a group at the upper part of the chart, as group A. A larger group, B, reacts with hydrochloric acid to produce hydrogen and a metallic chloride. A smaller group, C, beyond the second,

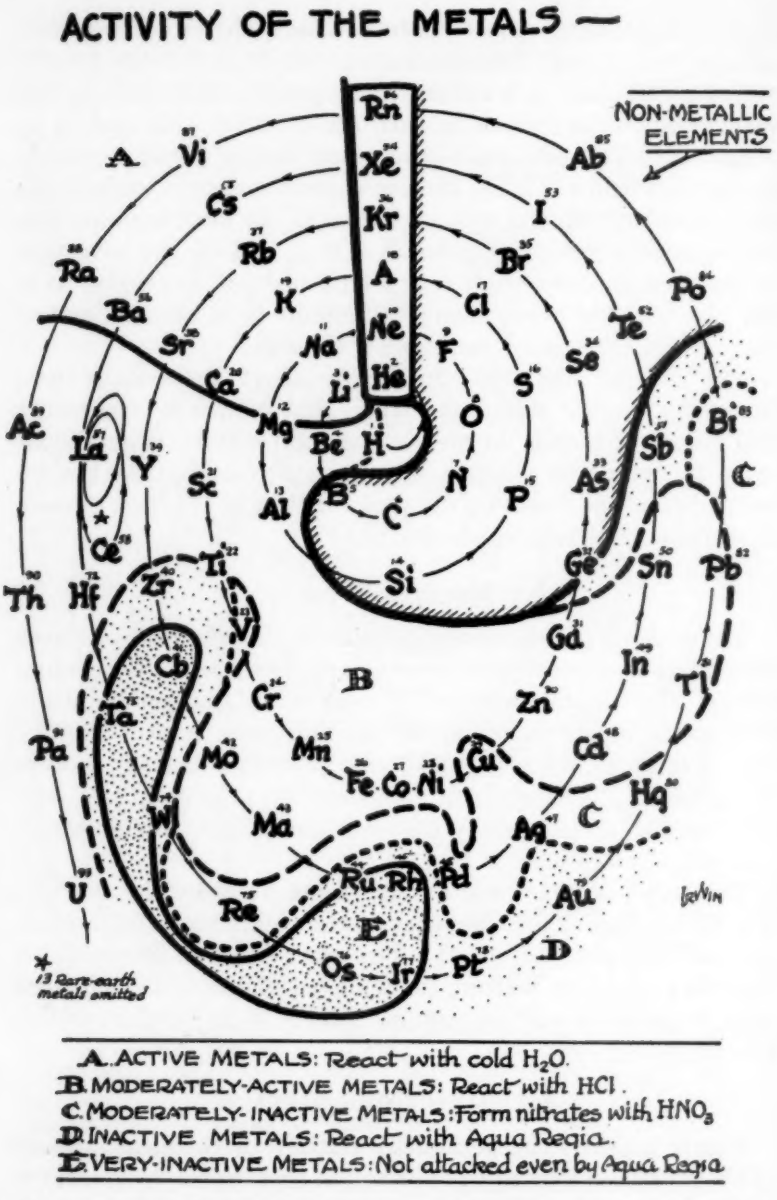

FIG. 6. Periodicity Pattern of Metal Activity. The most active metals form a group at the upper part of the chart. A larger group do not react with cold water to produce hydrogen, but displace hydrogen from hydrochloric acid; the least active of this group are near the lower margin. Smaller groups are chemically dissolved by nitric acid or aqua regia, leaving a very-inactive group unaffected by any of the chemical solvents mentioned.

reacts with nitric acid to produce metallic nitrates. (Certain metals in the vicinity of bismuth(83) and vanadium(23) form insoluble nitrates with nitric acid, so are attacked by the acid at least to a partial extent.) A still smaller number of metals, that include platinum(78) and gold(79), form metallic chlorides with aqua regia. Remaining as group E are the metals that are chemically so inactive that they resist the action of these chemical solvents; of these the one of greatest industrial importance is tantalum(73).

General Discussion

In looking over the periodicity patterns that have been shown it is evident that no common-type form runs throughout the series. The same would be true of the patterns of other properties. It is further evident that the members of what we call a chemical family of elements have certain properties that are in agreement and other properties that are widely variant, in numerous cases. In the classroom, experience has shown that the chemistry student gets a more adequate conception of the true relations that exist in such families through the use of a study of periodicity patterns than in any other less visual way.

POWDER FROM BEEF BLOOD STOPS HEMORRHAGE IN HEMOPHILIA

A powder from beef blood which stops dangerous bleeding in hemophilia was reported by Drs. Frederick J. Pohle and F. H. L. Taylor, of Harvard Medical School and Boston City Hospital, at the meeting of the American Society for Clinical Investigation.

The ever-present danger to a person suffering from hemophilia is the fact that his blood clots so slowly he may bleed to death from a small cut. The condition is hereditary, affecting only males but being transmitted through the mother.

The powdered substance from beef blood checked bleeding from external wounds and following tooth extractions in five hemophilia sufferers, Drs. Pohle and Taylor reported. The substance itself is a protein called globulin and was obtained from the fluid or plasma of beef blood. It is only effective when applied as a powder to the bleeding surface. It failed to hasten the clotting of the hemophiliac's blood when given by mouth, or to stop bleeding when used locally in solution.

This life-saving material, the scientists pointed out, is not yet available in large enough amounts for general distribution.

SOME PROBLEMS THAT MUST BE ANSWERED IN ELEMENTARY SCIENCE

By O. J. LuPone

Northport Public Schools, Northport, New York

A teacher in a rural community remarked to the writer, "My principal asked me to include elementary science in my teaching. I never had any training in science. Can you offer me some help?" From the conversation that followed this teacher was aware of the many problems which she was going to encounter. Needless to say, there are many teachers who are teaching elementary science who are confronted with similar problems.

Elementary science is slowly but surely making its way into the elementary school curriculum. This is indicative in New York State by the orientation course sent to village and district superintendents by the State Department of Education. The purpose of the course is to acquaint the teachers of the elementary school with science content, materials, *et cetera*, that might be included in teaching children. Not only is New York State realizing the need for elementary science in the grades but other states as well. This is brought out by the survey of Florence Weller (1) and her committee in 1933. The findings revealed an increase in interest in elementary science in 74% of 180 schools questioned. In view of the evidence that elementary science is becoming a part of the elementary school curriculum, the writer is cognizant of the problems that must be met and answered if any grade science program is to be successful. Since it is impossible to discuss all of these problems in such a paper, several have been selected that are pertinent. These are:

1. Conception of learning
2. Grade placement of content
3. Texts
4. Equipment
5. Testing and evaluation

PROBLEM 1—*Upon what conception of learning should a grade science program be based?*

All learning has a psychological basis. One is often bewildered by the various schools of psychology advancing theories regarding the principles of learning. It is true that current conceptions

of the principles of learning place emphasis on learning procedures that will result in direct and definable values. But what school of psychology offers the most satisfactory procedure? Does the bond psychology with its emphasis on specific learning or does the organismic theory of thinking with its emphasis on fundamental "wholes" offer the best procedure? Is learning the forming of stimulus-response bonds or is it discovering of organized "wholes"? Should all instruction be on the basis of a full analysis of subject matter or should it be on the basis of a process by which subject matter is molded into serviceable "wholes" which are made the goals of learning?

When one examines the work of Kohler (2) on apes the interesting thing to note in one of the experiments is the suddenness that the trial and error method is cut short for the execution of the proper act. In this experiment, the ape had two sticks which when properly attached would reach an objective. Even though the ape made many attempts unsuccessfully, it was not until the ape saw the relationship of the sticks that he succeeded. The Gestaltists would say that the ape exhibited "insight" or "discovery." The ape had performed a new movement rather than trying to improve on the old one.

Does the child learn in this manner? When the child sees the relationships of a topic or a problem does the problem or topic become more keenly conceived to him? And if the topic or problem represents a "whole" which is in the comprehension of the child, does he appear to learn the subject matter more easily?

Thorndike would rather be of the opinion that learning would result from a "belongingness" of sequences; that the second sequence evoke from the first. He states, "repetition of a belonging sequence have a demonstrable strengthening effect" (3). However, Dr. Davis points out, "What is learned is not always that which has been experienced most frequently or more recently, but that under certain conditions frequency and recency even operate to stamp out the response rather than enforce it" (4).

Many of our classroom teachers are confronted with this problem. Many have been trained in the school of bond psychology. What path should they follow?

Does the child learn by additions from day to day or by expansion or differentiation? Is learning a combination of both?

PROBLEM 2—*Should there be a rigid grade placement of content?*

According to most educators, grade placement of topics to be

studied in elementary science has been rather an opportunist one. Dr. Florence Billig (5) in her suggested outline of science content brings out the point for a need of extended study of grade placement of content. Yet, if one examines our better courses of study of elementary science, one will discover no generally adopted plan or sequence of areas to be studied. The facts seem to indicate that no criteria have been determined for grade placement of topical material. The question "what to teach" is still confronting our educators. And to add to the conflict there appears to be at the present time a controversy among the leaders and advocates of elementary science as to what should constitute the areas to be studied. One school of thought advocates "nature study" while the other school advocates science for social significance. On the other hand, there are leaders in elementary education who advocate that science content as such should not be included as a separate subject but rather an enrichment of pupil experiences. Needless to say, advocates of all these schools are influencing and moulding the minds of many classroom teachers of the elementary school.

Since many of our classroom teachers are in a measure their own curriculum makers the problem becomes more acute. Should they be guided by these leaders? Should they be guided by the "interests" of the children? Possibly the latter may be a start in the right direction, but as yet there has been no study that has revealed means of obtaining "true interests" of children. Rather the facts seem to indicate that interest studies have revealed no unity in content. Dr. Fitzpatrick in his study (6) points out the inadequacy of interests of children as true indices as they vary.

Is there a place for a rigid grade placement of topics? Invariably the answer would be "No." Should the teacher have a flexible program?

In the final analysis, whether the content for grade placement is selected from interest surveys or whether there is no fixed content, the teacher should bear in mind that any content is only as valuable as it meets the needs of the child and society. In other words, it should be science for social significance. The facts seem to indicate that much needed research is desirable in selecting the content that will adapt itself in a wide social sense. There is no doubt that much of our science content in the grades today is taught as science for science's sake

We are going through a period of curriculum reconstruction.

The grade placement of content for tomorrow of our elementary science should be chosen and placed in terms of its adaptability to the children's level interpreted, however, as to its value to the child and society. Problems that are the child's and problems in which the child can see the relationship to his daily living and to society should be a part of the new science in the curriculum. Thus, we can truthfully say our elementary science program is functional.

PROBLEM 3—*Should a grade science program be based upon a single text or upon supplementary texts?*

In light of Bagley's study (7) which reveals a " . . . surprising amount of justification for the prevailing opinion among American students of education that the class work of our public schools is still characterized by the formal mastery and reproduction of text-book materials," the problem of texts in a grade science program is pertinent.

Does the single text provide the child who has little or no background in science with material that is readily accessible? Does the child discover science material altogether difficult that can be easily assimilated? Is the science material written in such a style that even the dull boy can absorb it? Does the single text provide unity in science content that children can follow? On the other hand, would supplementary texts prove stimulating to the child since a great wealth of material is available? Is the material written in an interesting fashion and still comprehensible to the child? Does it treat a phase of science more adequately and fully than a single text? Does the child acquire a wider range of ideas through his probing into supplementary texts? Would the finding of extensive treatment of a particular area of science stimulate the child's imagination and interest and lead to a greater enrichment of the course?

Needless to say, there is value in both programs for a successful grade science program. No doubt, there are many teaching aids in our best grade science textbooks which facilitate their use as tools of learning. On the other hand, are we not thwarting the stimulation, imagination, and interests of children, who by extensive reading acquire a wider range of ideas? Even in the lower grades where unity of material tends to appear more effective would not several texts lead to a greater enrichment of the course to the child? Norem and Weideraenders, in their study (8) state, " . . . purpose of acquiring general information,

ability in problem solving, retention, comprehension of relationships; it is believed that an appropriate combination of intensive textbook reading and extensive supplementary reading gives the best results . . . " Thorndike (9) is of the belief, that for the majority of the pupils, supplementary reading must be used with caution and discrimination. Teachers often make recommendations to pupils of books that are too hard in respect to vocabulary. Consequently, the reading becomes work rather than play. If the child becomes identified with his interest, his reading for the solution to his problem which might be work then becomes play.

Perhaps there is no one answer to this problem. Consequently, the school must decide the path it wishes to follow according to the principles formulated in programs of science.

PROBLEM 4—*Should a grade science program experimentation be based upon commercially built apparatus or homemade apparatus?*

One activity which aids in the development in the use of the scientific method is experimentation in grade science. Children like to know the reason for the happenings of many phenomena; thus, experiments assist them in the interpretation of many principles of science. Consequently, apparatus is needed. Should the apparatus as maintained by one school of thought be purchased from commercial scientific houses? Can homemade apparatus bring out clearly the principles of science that children should retain from experiments? Can a piece of apparatus that has its origin in the five and ten cent store be adequate for experimentation? Does commercially built apparatus make least demand on the already busy teacher? Is there more learning when the child can feel, create, and construct his own apparatus?

Needless to say, there are relative merit and value in either the commercially built apparatus or in those which have origin in the five and ten cent store or are homemade. However, it appears that the inexpensive, crude and poorly constructed pieces of apparatus are often better than the expensive types. Inasmuch, as a successful grade science program is built around children's experiences, consequently, the children's experiences become more real and meaningful to them as they feel, build, and mould their project even though they have the earmarks of crudeness. The child is interested in the working and the demonstration of the project rather than the perfection of his piece

of apparatus. It is true that a makeshift apparatus may result into a waste of the pupil's and teacher's time, if the pupil is allowed to wander aimlessly without a plan of what he wishes to build. And as a result, the teacher might be inclined to resort to commercially built apparatus. Yet, on the other hand, if the teacher and the pupil are to grow with the subject, how can they do other than plan, create, and build much of their apparatus?

PROBLEM 5—*What should be the nature of an evaluation program in a grade science program?*

If a grade science program is to be carried out successfully in any school there should be some means for measuring values. Too often teachers take for granted that there has been growth in the child, that there has been some change in the child's behavior. But are they sure? How do they arrive at these conclusions? It is true that a child may retain and amass information and even know how to use it, but is one sure that the child will use this information advantageously when confronted with a situation? Will a performance test requiring the mastery of certain skills or abilities be an adequate measure? Can any one test be an adequate measure?

Since one of the goals of grade science is the development of attitudes, what proof can we offer that we are bringing about this development? Can it be measured by paper tests and observation records? If so, can we be sure that it was not influenced by an outside factor, e.g., home, teacher, etc.? Are we sure that it is a true attitude? There are those of the opinion that the intangibles can be measured by the rendering of paper tests based on a scale or by "free association" tests. The validity they claim is based upon and checked by observation, first a record of the child's behavior (anecdotal record) and by seeing the child while at work and by analyzing his written work.

Furthermore, can we measure growth of larger concepts or generalizations that we expect the child to have? Are tests needed to reveal what generalizations or concepts have been retained by the child?

Needless to say, these questions are perturbing to the classroom teacher. Consequently, if some means are utilized in measuring the results, it invariably results in determining whether the child has learned a quantity of useless facts. Isn't the teacher being hypocritical in directing her teaching towards certain

values and failing to discover if she has accomplished those values?

If we claim we are directing our teaching towards growth in the intangibles, should we not be honest with ourselves and discover some means by which we can assure ourselves that there has been growth. Too often we hear from our leading educators that we can not test for the intangibles. If we are honest, should we not attempt such testing? Perhaps the paper test which deals with attitudes is a step in the right direction. At least it is one means of focusing the teacher on the child. One fully realizes that attitude tests would not be as sufficient in this measuring as other means such as the anecdotal records, performance tests, classroom tests, informal talks by teachers, etc.; all play their part in this continuous evaluation.

The writer is of the opinion that these problems that have been briefly discussed in this paper should be answered if elementary science is to further receive recognition in the elementary school curriculum.

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THE USE OF PROBLEMS IN HIGH SCHOOL PHYSICS

By James G. Harlow
Northeast High School, Oklahoma City, Oklahoma

Through the years, physics has held an unenviable position among high school pupils as the most difficult of the sciences. Inherent complexity of subject matter has been an important factor in the development of this attitude, but there is another important factor in the situation: the lists of problems which characterize physics textbooks and which form an integral part of most physics courses.

To most pupils, the problems assigned in a physics course form the least pleasant part of the entire work; yet as a group we teachers are unable to teach successfully without them. A large part of the pupil's distaste for problems has, in the author's experience, arisen from the fact that the pupil only vaguely understands the educational process to which he is being subjected, and does not understand at all why he must solve appreciable numbers of problems in order to be successful in his physics course. This lack of understanding may often be overcome by a formal explanation, to the entire class in physics, of the purpose of physics problems. Such procedure uniformly improves the general attitude of the pupils toward their most tedious work in the course.

All of us are agreed that an ideal science class would result if unlimited time and equipment were available, so that each pupil could check each scientific principle or law several times, assuring himself of its veracity, learning to appreciate the experimental method, and fixing the law in his mind all at the same time. But practical situations abbreviate the ideal procedure, so that problems must be substituted for the several experiments on a single principle. This substitution for extended experimentation is the first duty of problems in elementary physics courses. In addition to serving as substitutes for large numbers of experiments, physics problems are called upon to exemplify applications of the scientific principles or laws under discussion. These two functions are separate and distinct, though the average set of physics problems makes no real effort to separate them.

In order to meet the first requirement of problems set out

above, it is necessary that each problem apply only one principle or law. When examined from this point of view, most of the problems given in the average textbook of physics are quite inadequate, since by far the majority of them require for solution the successive application of two or more principles. The beginning pupil is certain to experience confusion if he is asked to solve problems which require the co-application or successive application of two or more principles, especially when he is asked to apply the principles while mastering them, as he is in the average text in high school physics.

This situation may be remedied by writing a number of very simple exercises, each of which requires the use of only one principle for its solution, and assigning the group before the textbook problems are assigned. This method makes diagnosis of pupil difficulty easy and accurate; most other methods do not reveal failure in mastery of a single principle, but only possible failure in mastery of one of two or more principles. A mimeographed list of fifteen or twenty problems of the general type of "How many grams of water will be displaced by a 200 gm. wood block?" will often clear up pupil difficulties which cannot be located in the usual problems without a personal conference between pupil and teacher.

It is not intended to imply that the problem of two or more principles has an unimportant place in the teaching of high school physics, but rather that it should not be used as early in the development of the pupil as it usually is. Thorough mastery of a given principle should first be effected with the aid of simple problems before the principle should be applied in conjunction with any other principle.

In like manner, problems whose purpose it is to exemplify applications of principles should be made in terms of specific devices, not as complicated statements of theoretical, unimportant experiments. Again, most textbook problems fail to meet this objective of problems. We find such problems as, "A rod held in a north-south position has forces of 10 gm. and 20 gm. acting at distances of 25 cm. and 50 cm. respectively from the north end of the rod. Where must a force of 30 gm. be placed in order to keep the system from rotating?" This sort of problem presents a severe difficulty in visualization, in addition to the actual knowledge of physics necessary to solve it. The objective of this problem, evidently to furnish an example of the application of equilibrium conditions, could have been

attained by a simple straight line drawing without introducing the extraneous difficulty of visualization.

A serious teaching difficulty presents itself in the actual use of any physics problems, including those of the simple type described earlier. This difficulty arises from the pupil's ability to use formulas. Strange as it may seem, most high school pupils have learned one skill so well that it actually interferes with their learning of physics—that of the mechanical use of formulas. Most physics problems may be solved easily by mere formula substitution. This fact leads pupils to depend entirely on their previously developed skill in the use of formulas for their solutions of physics problems. In actual operation a pupil often reads his problem, then looks back through his text to find the formula which contains the factors given by the problem and the quantity asked for; then without further work he substitutes the problem quantities in the formula of the textbook and runs through the necessary manipulation to solve the resulting equation. No thinking in physics actually occurs. The simple problems described earlier will overcome this difficulty; if correctly written, they will not lend themselves easily to blind solution by formula, and will reduce the problem complexity to a point at which the pupil will not need to rely on formula skill for problem solution.

In addition, most textbook problems in physics are unnecessarily complicated with cumbersome arithmetic. It has been the experience of the author, as well as the experience of those with whom he has discussed this problem, that arithmetical skill is, under present conditions, at least important in the pupil's attainment of success in physics. It is not necessary for physics problems to be arithmetically difficult in order to be good physics problems. In fact, difficult arithmetic tends to obscure the principle being applied or exemplified, since it is necessary for a time for the pupil to concentrate on arithmetical manipulation to the exclusion of everything else. It is slightly more difficult to devise two step or more complicated problems whose numbers bear integral relations to each other, but the labor is justified by the improved efficiency of the problems.

Of course the textbook problems cannot be abandoned, for a busy teacher does not have enough time to write an entire set of problems for a physics course. But writing the simple problems described above is a rather simple matter, and if they are written, the instructor can let them carry part of the problem

load and then select the best of the text problems for his final applications of physical principles and laws.

Any physics teacher who wishes to test the conclusions made here may write for himself a group of fifteen or twenty problems, each involving only one principle, with its numbers selected so that the necessary arithmetic is confined to the multiplication tables below ten, and give the group to his pupils in the form of a test or drill exercise. The results will be illuminating.

SOME OTHER IDEAS ABOUT THE SUBTRACTION OF SIGNED NUMBERS

By John O. Pyle
Chicago, Illinois

Granting that Mr. Tate's method of teaching the subtraction of signed numbers[1] is both ingenious and workable, the reason he gives for resorting to this method seems to me a mistaken judgment. He says, "Neither arithmetic nor out-of-school experience provides a background for algebraic subtraction."[2] I have always believed just the opposite true, and have taught accordingly. Let me make one more effort to show the close connection of algebra and arithmetic, and the adequacy of "out of school experience" for illustrative material.

The addition and subtraction tables by which we find sums and remainders in arithmetic, though sufficient for addition in algebra, are entirely inadequate for subtraction. On this account we are driven back to simpler processes, just as the pupil was in arithmetic before he or she learned the tables and their uses. We must get our sums and our remainders by mere counting.

The addition problem is: given two addends; if the number indicated by one is counted on to the other, with what number do we stop? This last number is called the sum of the two given numbers. Either addend can be used for the starting number, it makes no difference in the sum.

The subtraction problem is: given a subtrahend and a minuend; what number must be counted on to the subtrahend to reach the minuend? The answer in this case is called the re-

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[1] Tate, M. W. "Teaching the Subtraction of Signed Numbers," School Science and Mathematics, October, 1937, pp. 837–839.

[2] *Ibid*, p. 837.

mainder. If the minuend be taken for the starting number the remainder is not the same, unless the subtrahend and minuend are equal numbers. In that case the remainder is always zero.

Mr. Tate's so-called "check"—"Subtrahend plus Remainder equals Minuend"[3]—is, of course, just the relation of the three numbers involved in any subtraction problem. The addition relation is: addend plus addend equals sum. In the subtraction problem it is the remainder we do not know; in the addition problem we do not know the sum.

In arithmetic the counting proceeds in only one direction; namely, from any starting number, toward ever increasing numbers, along the ordered number scale. In algebra we count in either of the two ways along the signed number scale according as the problem demands. The sign of the number counted determines the direction of the counting. If the sign of the number symbol is (+) the counting proceeds toward the positive end of the number scale; if the sign of the symbol is (−) the counting proceeds toward the negative end of the number scale.

It should be noted that the plus (+) and minus (−) signs in the use of signed number symbols sometimes indicate merely to which side of zero the number symbol belongs, and sometimes indicate in which direction the counting proceeds. In addition the starting addend and the sum are position numbers; but the other addend is a process number, so the sign indicates direction of counting. In subtraction the subtrahend and minuend are position numbers; while the remainder is a process number, so its sign indicates direction of counting.

So much for the close connection between algebra and arithmetic. For illustrative material from out-of-school experience for use in class, the thermometer has always appealed to me as most excellent. Everybody is familiar with the thermometer, and with newspaper reports of daily temperatures. The scale along the mercury column is the signed number scale. The newspaper reports make use of signed numbers. The plus, (+), numbers are above zero. The minus, (−), numbers are below zero. The top of the mercury column rises and falls. Changes upward will be measured by positive numbers; changes downward by negative numbers.

Now, without making any change in the meaning of subtraction as used in the arithmetic, except that we shall count in either direction according as the problem requires, what hap-

[3] *Ibid*, p. 838.

pens when we use the signed number scale for solving problems of temperature changes? The problem is a subtraction problem when the reading of the thermometer is given for two different times and the question is: what was the amount of change in the mercury column and what direction did the top of the column move?

Examples: 1. If last night the thermometer reading was $-3°$ and this morning it was $+5°$, what was the change of temperature? The Algebra question is: if you count along the scale from $-3°$ to $+5°$, how many spaces must be counted and in what direction does the counting proceed? The answer is $+8°$. The degree (°) is the specific name of a space, 8 is the number of counts, and the (+) indicates the counting was upward. So the answer to the given problem is, the temperature rose 8°.

2. If the temperature this afternoon was $+3°$, and by dinner had fallen to $-5°$, how much was the drop? The Algebra question is: If you count along the scale from $+3°$ to $-5°$, how many spaces must you count and in what direction does the counting proceed? The answer is $-8°$. So the answer to the given problem is: The temperature dropped 8°.

A list of all possible types of combinations of numbers occurring in subtraction problems with the thermometer is a short one. Thus, omitting the degree sign, and using merely the abstract number symbols: How far, and in what direction

from -3 to $+5$? Answer $+8$.
from -3 to -5? Answer -2.
from $+3$ to $+5$? Answer $+2$.
from $+3$ to -5? Answer -8.
from $+5$ to -3? Answer -8.
from $+5$ to $+3$? Answer -2.
from -5 to -3? Answer $+2$.
from -5 to $+3$? Answer $+8$.

It would be possible to construct adequate tables for all the combinations of one digit signed numbers and memorize them, as is done in arithmetic for the ordinary number symbols. A much easier method is almost obvious. Observe the list given. It is easily seen that the answers, so far as the abstract number symbols are concerned, could be obtained by changing the sign of the subtrahend in each case, and then adding the two numbers in accordance with the rule for algebraic addition. Hence, the conventional rule for algebraic subtraction: change the sign

of the subtrahend and add, algebraically. The combined addition and subtraction tables, as learned for arithmetic, are adequate for algebraic additions. Since every subtraction problem can be changed to an addition problem, no new tables are needed.

The use of signed numbers in problems requiring subtraction to compute changes in other phenomena is as simple as that given here for changes of temperatures. The problem of finding a neutral point among the values treated, so that equal quantities on each side of this neutral point shall equal zero when balanced against each other, is a problem of intelligence. Scientific training helps the student in this aspect of his studies, but there can be no guarantee for his success. It is not a problem, primarily, belonging to algebra.

SOME EASY PROJECTS IN CHEMISTRY

Project 3, Glass Lettering

By Margaret Shriver and Edward McLeod
Senior High School, Orlando, Florida

Glass lettering is very easy and interesting to do. First get the desired piece of glass on which you wish to etch the letter. Wash the glass and dry it thoroughly. An aluminum stencil with the desired letter cut out in the foil is then heated to soften the adhesive on the back of the foil. Just warm gently. Place the stencil in the desired position on the glass and with a hard smooth surface, like the bowl of a spoon, press the stencil firmly against the glass so that it adheres closely.

Then apply a small amount of the paste called Etchall.* This comes in a tube like tooth paste. Spread the paste carefully on the cut-out letter, working it into all parts of the design; use a match stick or a small swab to do this. Do not let the paste get over the edge of the stencil as it will then etch where you don't want it to. This paste is left on for about five minutes, then washed off with hot water. The warmth loosens stencil and it is then possible to pull it off carefully. The stencil can be used again several times. The glass surface is now washed with some good scouring soap and hot water. After the glass has been wiped dry the letter appears very plain and will never come off.

* The address of the manufacturer will be furnished on request.

A METHOD OF REVIEW

By Isadore M. Ziff
Philipsburg, Pennsylvania

For a number of years I have been using a method of review in my general science classes that has been very helpful. The students prepare questions on the units to be covered in the review. In class they call on each other for the answers. When a student answers a question correctly he is permitted to ask another person a different question. If a question is asked which cannot be answered by anyone else this person who has asked the question must answer it. If he cannot answer the question he is not permitted to ask any more questions. If this question cannot be answered we all look it up in the book.

Last year I tried this method in the form of a spelling bee. The questions were prepared as previously explained. The students called on each other in the same way also. However, if they failed to answer the question correctly, they had to stand up along the side of the room. About halfway through the period, those remaining at their seats were permitted to call on the others who were standing in the line, beginning with the one at the head of the line and so on down the line. If a person answered a question correctly, he was permitted to sit down. Only those students who are seated may ask questions.

Another variation of this idea is to have boys call on girls and vice versa. When a boy calls on a girl who is seated, she must answer the question correctly or stand in line on one side of the room. If she answers the question correctly, she may ask a boy another question. If he answers it he remains seated and then asks another question of a girl. Should he fail to answer the question he must stand along the opposite wall. This girl, who asked the question, then calls on another boy. All those boys who fail to answer must stand up, until finally a boy does answer the question.

This has stimulated very keen rivalry. They are interested in seeing whether there are more of one sex seated than of the other sex. After a certain period of time, if there are more boys seated than girls, the boys are declared the winners of that part of the contest. Should there be more girls seated at that time, they are declared the winners.

Then the idea becomes one of seeing which group will have the least number standing at the end of the period. For now

the boys and girls who are seated call on a person of the opposite sex who is standing. In other words the girls, who are seated, call on the boys who are standing; while those boys who are seated call on the girls who are standing. The person who answers a question correctly is then permitted to sit down. Should a boy answer a question, he sits down and any boy who is seated at the time is permitted to call on the girls who are standing—beginning with the first one in the line and continuing down the line until the question is answered.

This second part of the review is a sort of consolation tourney. It is quite possible for both groups to win in one period. If the review covers more than one day, results of successive days can be compared and a final winner can be declared.

Another way to use this review is to start out with the boys grouped in a line along one wall and the girls standing along the other wall. With their questions in their hands, they call on each other. Answering a question correctly permits a student to sit down. This student then asks a question of a person in the opposite line. This can be continued for the entire period. Rarely, if ever, does everyone get seated in a period. If more girls than boys are seated at the end of the period, the girls are then declared the winners.

Still another way is to have all those students who made 80 or less for their six weeks' grade stand in one line; in the other line along the opposite wall those who made 85 or more stand. They can call alternately on each other. Those who answer correctly sit down and then call on a person in the opposite line. This certainly demonstrates why some students get low grades, for these students usually are standing at the end of the period.

They also can be grouped by teams of odd and even rows. Or captains can be selected, who will pick sides for the event. The best students ought to be captains. One big fault of picking sides is that it takes up too much time.

The rivalry between groups is very keen so that it is important to keep control at all times. They often have wrong ideas as to what constitutes a correct answer. Occasionally they insist on having a certain word or group of words as the only answer. There ought to be a definite understanding before the period begins as to the types of questions that may be asked.

Pupils generally prepare good lists of questions and cover almost all the material in the units or chapters. This type of review tends to put the emphasis on the pupils and not the

teacher. After all it is the students who need the review. They have said that this type of review makes them study more than they ordinarily would. They don't like to stand. Others take great pride in not having to stand during the class period. One boy said, "I stood today, but I'm going to study tomorrow."

THE DISPLACEMENT SERIES

A Demonstrational Experiment

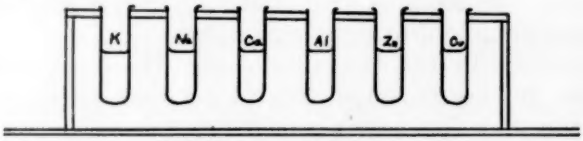
By Charles H. Stone
Boston and Orlando

Certain principles of chemistry are not capable of proper demonstration at the teacher's desk. One can hardly demonstrate the structure of the sodium atom or the principles expressed in Avogadro's Law. On the other hand, there are numerous cases where the principle under consideration can adequately be demonstrated. Among these important topics is that of the displacement, or electromotive, series of the metals.

This series is of such importance that it would seem advisable to introduce it into the elementary course much earlier than is customary. An examination of several of the leading chemistry texts used in high and private preparatory schools shows that in numerous instances this series is not introduced until rather late in the study. The following table shows the page of introduction, and also the page on which the study of hydrogen begins. The difference between the page numbers shows how much ground is covered between the chapter on hydrogen and the place where the study of the displacement series is taken up.

Text examined	Hydrogen begins	Displacement series
Text A	page 30	page 591
Text B	" 51	" 216
Text C	" 72	" 425
Text D	" 33	" 441
Text E (college)	" 35	" 158
Improvement is shown in some recent texts		
Text F	" 69	" 76
Text G	" 42	" 51

It seems to the writer that the displacement series may well be introduced in connection with the study of hydrogen. Pupils will ask: "Is iron as good as zinc for preparing hydrogen?" "Could copper be used as the metal?" "Why are the sink-traps in the laboratory made of lead which is a soft metal instead of iron which is a hard metal?" "Could you use aluminum to make hydrogen?" And similar questions. Of course, the teacher can give some sort of oral explanation, but why not show the actual facts of the case by a simple and easily performed demonstration experiment?



Displacement Series.

The apparatus for the experiment is very simple. Procure a strip of board about two inches wide and bore holes at regular intervals, making the holes of such size that a fairly large test tube will just slide through and be supported by its lip. Holes may be about two inches apart and as many may be bored as are desired. The two ends of the board are to be supported in any convenient way, either by resting upon the tops of two bottles of equal height, or by wooden supports as indicated in the accompanying sketch. Each tube should contain about 10 ml. of cold water.

a. Into the first tube, drop a very small bit of dried potassium. The action will be very violent, the heat generated being sufficient to set fire to the hydrogen which is set free by the chemical action. The characteristic flame color may be observed through cobalt glass.

b. Into the second tube, drop a bit of dried sodium. The action is vigorous, but less so than with the potassium. The hydrogen may be ignited, but often is not.

c.[1] Into the third tube drop a bit of calcium free from oil. Calcium is so hard that a pair of heavy shears, or a cold chisel and hammer may be needed to cut off a small piece. The action is moderate; hydrogen is liberated and presently the white hydroxide may be seen forming in the tube.

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[1] Recent research indicates that calcium *precedes* sodium in the series. (Private information from a representative of the research group.)

d. Aluminum. Since water is often boiled in aluminum tea kettles and other vessels made of aluminum, it may be thought that this metal does not act on water. However, if the film of oxide be removed from its surface, the metal will react. To remove the film, amalgamate the aluminum. Put about one gram of aluminum grains into a tube with 5 ml. of dilute mercurous nitrate solution. The liquid becomes dark-colored. Pour off this liquid and add another portion of the mercurous nitrate solution, continuing until the liquid is no longer colored and runs off clear. Now introduce into tube #4 some of the amalgamated aluminum. The action is slow, but hydrogen is given off and white aluminum hydroxide is seen to form.

e. Into the fifth tube drop a bit of zinc. There is no indication of action. It may be interesting to amalgamate some of the zinc and see how that reacts with the cold water.

f. Into the sixth tube drop a bit of copper. No action is evident. The illustration shows six tubes in position, but it is obvious that a larger number of holes may be provided so that the action of other metals than those indicated above may be shown.[2] The lower end of each tube should not rest on the surface of the desk, as the figure shows.

Now the most stupid pupil in the class can hardly fail to see how the action of the various metals indicated above steadily diminishes: also that in all cases where action is seen, hydrogen gas is given off.

Returning now to tube #1, add a few drops of phenolphthalein solution. The characteristic red color appears showing that a base is present. Add the indicator to each of the other tubes. In tube #4, no color change is seen because aluminum hydroxide is not sufficiently soluble to give hydroxyl ions enough to show the color change. It appears from the above part of the experiment that when a metal acts upon water, hydrogen is liberated and a hydroxide is formed; if the hydroxide is soluble, we call it a base.

For the second part of the experiment, the action of various metals on hot water or steam may be shown. Magnesium ribbon will burn in a flask filled with steam. Zinc and iron dusts will react with steam to form hydrogen and oxide of the metal. Separate apparatus will, of course, be needed if this part of the experiment is to be shown.

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[2] Powdered magnesium is excellent. ED.

For the third part, remove the test tubes and replace them with others, each containing 5–10 ml. of concentrated hydrochloric acid. This acid is used because it is highly ionized and does not have any oxidizing action on the metal. Nitric acid, obviously, could not be used.

a. Into the first tube, drop a bit of aluminum or magnesium. The action is vigorous with evolution of hydrogen.

b. c. Into the second tube drop a bit of zinc or zinc dust and into the third tube drop a few iron tacks or some iron powder. Observe the difference between the action on the zinc and the iron; hydrogen escapes in both cases.

d. Into the fourth tube drop a bit of tin (granulated). Observe the action.

e. Into the fifth tube drop some bits of copper free from oil. Observe any action.

f. Into the sixth tube, drop a bright dime (preferably borrowed from a student. He will think he will never see that money again!) Note action.

If desired, lead and mercury may be shown, additional tubes being provided for that purpose.

Here again, the class can hardly fail to observe the steady decline in the activity of the metals shown toward the acid used. Also it will be seen that where action does occur, hydrogen is given off. It will be evident that aluminum is not suited for use, for the action is too vigorous; finely powdered zinc and iron dust also are not advisable to be used. Copper does not react at all. Lead should react, feebly, but the insolubility of the lead chloride tends to clog and finally to stop the action. Such questions as those indicated early in this article can now be answered satisfactorily by the students themselves from the observed facts.

When the experiment is over and has been fully discussed from its various angles, produce your Displacement Chart. Let comparisons be made of the list as given in the chart with the results observed by actual experiment. The verification of the chart should easily be established. The teacher, to clinch the matter, may require a written report on this experiment from each member of the class. Properly conducted, this experiment will be found to be well worth while in making clear certain fundamental points as to the activity of the principal metals.

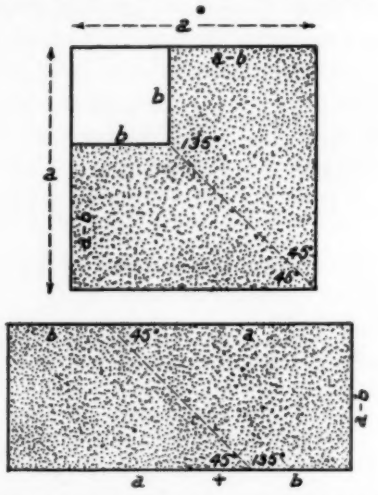
Finally, wash and dry the dime and return it to Johnny.

PICTORIAL REPRESENTATION OF

$$a^2 - b^2 = (a+b) \cdot (a-b)$$

By FRANZ DENK

[Reprinted from *Unterrichtsblaetter für Mathematik und Naturwissenschaften*, Number 1, 1938. Verlag Otto Salle, Frankfurt am Main.]



This reprint taken from a German journal is self-explanatory. It is simpler than the traditional presentation found in several of our well known algebras and geometries and will undoubtedly make an instant appeal to student's of high school mathematics.

A. A. SPERLING

NEW INDUSTRY GROWS AROUND SILICA BLACK

A new industry is growng up around "silica black," a new carbon and silicon-bearing material derivative discovered six years ago by Prof. C. A. Jacobson of West Virginia University.

Produced when coal and a material like diatomaceous earth are mixed and distilled at 600 degrees Fahrenheit, "silica black" is an inky-dark powder for which a wide variety of uses is being found, Dr. Jacobson reports.

It is being used as a filler to give paints durability and the ability to resist heat. It is finding application as a supporting medium for finely-powdered nickel, used in chemical process whereby hydrogen is added to vegetable oils to make edible fats.

Use as a reinforcing pigment in rubber and plastic molds has also been found. Its high temperature resistance qualities have enabled manufacture of a gasket paste with it that can be used on metal joints which, when heated to nearly 1,000 degrees Fahrenheit, will keep the gaskets from burning up. The paste is also useful in applying heater hose in automobiles, on joints in contact with various types of solvents and vapors.

An acid-proof paint that withstands both acid and alkali conditions and that can be applied to metal, wood or stone without a primer, has also been developed.

WHAT ARE SOME OF THE BENEFITS OF MEMBERSHIP?

Never before in the history of the teaching profession has there been such an urgent need for teachers to keep abreast of the times. This is especially true in science, where teaching methods, procedures, recent discoveries, and developments in the fields of science change almost over night.

The teacher of today cannot rest back in an easy chair after his graduation from college or university and say, "I've prepared for my life's work." Such an attitude will cut short his usefulness in this great enterprise of education.

The scheme of science and mathematics education will function best, not upon the individual effort of one teacher, but upon the cooperative effort of all teachers in any particular school system. This points out, that a science or mathematics teacher in any school system, in order to function efficiently in the educational effort of these fields, needs to know what is being done in elementary, junior high, senior high, and college science.

The relationships between all fields of science and mathematics are so many and so close that the teacher of today, teaching in any specific field, finds it necessary to know *much* about all science and *more* about his specific field.

"Keeping up" is a gigantic task. Reading widely in the field of education and science seems an almost insurmountable problem to busy teachers. This problem more than justifies the place and purpose for such an organization as "Central Association of Science and Mathematics Teachers." It is an organization with a journal containing articles on method, procedures, and the latest developments in science and mathematics, carefully selected for the benefit of its readers. It is an organization that draws its membership and contributors, not from a small locality, but from several states; an organization large enough to support annual meetings that have on their programs the outstanding personalities in the different fields. It is an organization that offers the teacher contacts with science and mathematics teachers from a widespread area.

The price of membership *is indeed small* when the manifold benefits of the association are considered. The question is not, "Can I afford to join?" It is, "Can I afford to be without it?"

T. A. NELSON
(For the Membership Committee)

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EASTERN ASSOCIATION OF PHYSICS TEACHERS

One Hundred and Thirty-Eighth Meeting

HARVARD UNIVERSITY

Jefferson Physical Laboratory, Room 250

March 5, 1938

PROGRAM

9:45 Meeting of the Executive Committee.
10:00 Report of the Secretary.
10:15 Report of the Delegate to the American Science Teachers Association. Mr. Homer W. LeSourd.
10:30 Address by the Vice-President, Mr. John P. Brennan.
10:45 Lecture: "How the Bohr Theory Explains the Hydrogen Spectra." Professor Otto Oldenberg.
11:30 Informal Talk: "The New Harvard Cyclotron. What It Is—How It Works—What It Is To Be Used For." Dr. Roger W. Hickman.
12:00 Discussion: "Measuring Noises in Every-day Life." Professor Frederick A. Saunders.
1:00 Luncheon.
2:00 An Inspection of Some of the Researches Now in Progress:
The Cyclotron and the Mass Spectrograph.
Assistant Professor Kenneth T. Bainbridge
Cosmic Rays
Assistant Professor J. Curry Street
The 21-foot Grating Spectrograph
Professor Otto Oldenberg
The Van de Graaff Electrostatic Generator
Dr. Ivan A. Getting
3:00 Short Talk with Demonstrations: "Some Useful Demonstration Apparatus." Assistant Professor N. Henry Black.
3:30 Lecture with Demonstration and Motion Pictures in Color: "The Experimental Study of Sounds Made by Insects." Professor George W. Pierce.

OFFICERS

President, Ralph H. Houser, Roxbury Latin School, West Roxbury, Mass.
Vice-President, John P. Brennan, High School, Somerville, Mass.
Secretary, Carl W. Staples, High School, Chelsea, Mass.
Treasurer, Preston W. Smith, 208 Harvard St., Dorchester, Mass.

BUSINESS MEETING

The following were elected active members.

James W. H. Baker, High School, Gardner, Mass.
Kenneth C. Ballard, Lawrence High School, Falmouth, Mass.
James J. Cotter, Senior High School, Chelsea, Mass.
Harry A. Johnson, High School, North Brookfield, Mass.
E. Victor Knapman, Newton High School, Newtonville, Mass.
Ralph Libby, Belmont Senior High School, Belmont, Mass.

Wendell M. Osgood, Dean Academy, Franklin, Mass.
George W. Seaburg, Hyde Park High School, Boston, Mass.
E. Montgomery Wells, Brookline High School, Brookline, Mass.
Edward W. Whitmore, Scituate High School, Scituate, Mass.
Emerson A. Wiggin, South High School, Worcester, Mass.

The following were elected associate members.
Max O. Brown, Central Junior High School, Milton, Mass.
William J. Dee, East Boston High School, E. Boston, Mass.
Miss Grace P. French, Senior High School, Lexington, Mass.
Professor Carl A. Pearson, Simmons College, Mass.
Wallace W. Sawyer, Weston High School, Weston, Mass.

It was voted that the Association extend to the Physics Department of Harvard University and to Professor Black its thanks for entertaining us at our 138th meeting and our appreciation of the hospitality shown us.

Mr Houser announced that the 139th meeting will be at the new high school in Newburyport, Massachusetts.

He offered a tentative program which was approved by those present. His suggestion was a morning program consisting of reports of committees, and a debate on the subject perhaps of "Mathematics in College Requirement." He asked for advice in regard to formulating the question, but might debate "Resolved: That College Board Requirements Should Be Less Mathematical."

The suggested afternoon program was to consist of an address or visit to some of the industrial plants in Newburyport. The Association would be welcome, he said, at the town silver shop (manufactures silver-ware, but details not known) and also at the Caldwell Distillery. He said that suggestions would be welcome.

REPORT OF THE DELEGATE TO THE AMERICAN SCIENCE TEACHERS ASSOCIATION

Mr. Homer W. LeSourd spoke briefly on the recent meeting of the American Science Teachers Association with which the Eastern Association of Physics Teachers voted to affiliate at the meeting on December 11, 1937.

He said that the American Association for the Advancement of Science has 18,000 members, 15 sections and 123 affiliated societies largely composed of professional scientists. For some time it has had a committee on the place of science in education. The American Science Teachers Association has received substantial aid from the larger organization. Its aim is to unify the whole group of secondary school science teachers in America and to draw out leadership from the local organizations such as ours.

The new organization at the Indianapolis meeting had a notable program; in one session three Nobel prize winners gave addresses. Dr. Arthur H. Compton, Dr. W. M. Stanley and Dr. Harold C. Urey, while at the luncheon which followed there was a speech by Dr. George D. Birkhoff, president of the American Association for the Advancement of Science. The meeting next year is to be held at Richmond, Virginia and Mr. LeSourd expressed the hope that our association might send a large number to that gathering.

ADDRESS BY THE VICE-PRESIDENT

MR. JOHN P. BRENNAN

It is my intention to speak very briefly on the topic: Some Aspects of Teaching Physics in Secondary Schools. I say "very briefly" for a very cogent and sufficient reason. When President Houser wrote me relative to this meeting, he referred with great enthusiasm to the program which Professor Black has prepared for us. To use President Houser's own words, the speakers whom Professor Black has secured for our meeting today constitute "the cream of the Harvard Staff." Surely you will agree with me when I say that the pleasant memories and the substantial profit that we all have derived from our previous meetings, here at Harvard together with the anticipation of what is in store for us today is more than ample justification for the brevity of my remarks.

It has been recently pointed out that while the use and application of mathematics to our everyday life is increasing very rapidly, the emphasis placed on mathematics in scholastic circles is steadily decreasing. Now, if these two statements are true, they contain, I think, rather important implications for us physics teachers. For, if mathematics is the language of science, and especially of physics, any fundamental movement in the one field is sure to be reflected in the other.

At first sight it might seem that the effect of any such a movement on the teaching of physics in secondary schools must necessarily be detrimental. For, if one cannot use and understand the language of physics, what progress is possible in the science itself? Personally, I am rather strongly in favor of the study of mathematics, not only for the sake of the subject itself, but also because it is such an excellent vehicle for the expression of the facts and principles of the natural sciences as well as a fine instrument in the general educative process. Yet, I do not believe that a diminishing emphasis on mathematics must necessarily be detrimental to the study of physics in the secondary school. My reason for so thinking is based on the fact that, broadly speaking, pupils who take physics in these schools may be divided roughly into two classes. The first group is made up of those pupils who have a natural bent or flair for the subject, the "scientifically-minded" pupils, who with a good grounding in mathematics bring to their study of physics that genuine interest and enthusiasm that is the joy of a teacher's heart. That type of pupil I mean who, in his own words "just eats up the stuff." We all know what satisfaction and pleasure there is to be derived from a class made up of pupils of this type. The second group is made up of those who take the subject because "it counts for five points toward graduation" or because "a friend took it" or because "some teacher suggested it" to him or because somewhere in the back of his head there is a foggy notion or yearning to be "an engineer of some sort or an airplane pilot" and in some vague way he has come to realize that to accomplish this end he must take physics.

The first group we do not have to worry about. Let us thank God for

them and enjoy their delightful company as we pilot them along their voyage of discovery as others in the past have guided us. But the other group! There lies our problem. And what a problem it seems to be at first! I trust you will not think me presumptuous when I say that I do not believe that the problem is as great as at first appears and that the solution is so difficult of attainment. To my way of thinking the solution to this problem is bound up in two factors, one a negative factor which must be removed and the other a positive factor which must be cultivated and developed. The negative factor which must be removed is a fear or apprehension about the subject of physics. This fear is due, I think, partly to a tradition that has been handed down by those who fared poorly in the subject, partly to the vocabulary difficulty, and partly, and I think in large measure, to the problem difficulty. About the tradition that has grown up about the difficulty of the subject of physics not much can be done, I fear, unless we supplant this tradition with the fact that physics is about the most interesting and most useful subject in the whole curriculum. The response of pupil audiences to the exhibition of the Preview of Progress sponsored by the General Motors Corporation is indicative of what can be done. It is true that we may not have all the material advantages which those lecturers enjoyed but I believe there is much that we can learn from their manner of presenting their subject. I know of a teacher who has been rather successful in dispelling the apprehensions of his pupils by smilingly telling them that the principle or theory that seems so hard to them at first is really "a cinch." Then he goes on to show them that it really is "a cinch." This is done in many and various ways. Are there strange and meaningless words in the principle they are studying? Does Boyle's Law state that the volume of an enclosed mass of gas at constant temperature varies inversely with the pressure exerted on it? 'Inversely!' What does 'inversely' mean? Why that means 'upside-downly.' Then with a simple little illustration on the blackboard the lesson is driven home. "If we multiply the pressure on the gas by 2, we have to multiply the volume of the gas by ½. 'See!' 2 turned upside down is ½." With him a stable object is something that will 'stay-put,' while permeable becomes 'pass-through-able'; a permeable membrane is one that liquids can pass through; and notice above how easy it is to do problems. Thus does he cajole them out of their fears and dispel the ignorance that gives rise to them. Livy it was, I think, who wrote "Omne ignotum pro magnifico."

The positive element that must be cultivated and developed is interest. This is, to be sure, a very, very old principle of pedagogy. But it is none the less true for that. We all admit the principle. The question is how is interest to be cultivated and developed. One sure way not to do this is to stick slavishly to the textbook. Personally, I believe one of the best ways to arouse and sustain the interest of pupils in this second group is to appeal to their imaginations. I know this may sound like heresy, since physics is supposed to be one of the exact sciences, being based on sensible experience and justified by reason. Nevertheless, a properly cultivated

imagination can be of immense value to the intellect in its search for the truth hidden in a mass of experimental data. Do we not have picture books for young children, illustrations in our textbooks? Why not push this one step further and present a principle or a law as it actually is being worked out in actual life? The use of demonstration apparatus is an attempt to do this, but effectiveness is often impaired, if not entirely nullified, by the complexity of the apparatus or the artificiality of the set-up. I would suggest that actual cases illustrating a principle to be taught be presented to the class in as vivid a manner as possible. Such books as *On The Bottom* by Commander Ellsberg in which is related the salvage of the ill-fated submarine *S-51* and *Little America* by Admiral Byrd and many other similar works contain a vast store of material for such a program.

If we would be more careful to present the subject of physics as we see it round about us in our everyday world, we would not have to see with regret our classes becoming smaller while pupils crowd into other classrooms. This is not said with any envy of the success of other teachers or disparagement of other subjects, but rather from the conviction that physics really is a very worth-while subject in the curriculum of the secondary school not alone for its utilitarian value but because it can reveal to growing young minds a more complete and harmonious picture of this marvelous material creation round about us, whose wondrous glory and exquisite order moved the ancient Greeks to call it *o'κόσμος*, the Beautiful, and because we know that this fuller knowledge and deeper appreciation of our material heritage cannot fail to make them better men and women.

BOHR'S THEORY OF THE HYDROGEN ATOM

PROFESSOR O. OLDENBERG, *Harvard University*

This year marks the twenty-fifth anniversary of Bohr's theory of the hydrogen atom. It is the purpose of the present discussion of this theory to make clear its background and the principal idea rather than the mathematical detail.

The topical outline—as it was given on the blackboard at the meeting of the Eastern Association of Physics Teachers—is given here as Table 1.

I. EXPERIMENTAL RESULTS

The aim of Bohr was to explain the origin of the bright-line spectra emitted from gasses under the action of electric discharges. The hydrogen atom offers the best chance for a solution of this problem because it has the simplest spectrum and, moreover, is the lightest atom, so that it is believed to have the simplest structure. The spectrum of hydrogen (Fig. 1) consists of several series of lines, one of which can easily be observed in the visible and near ultraviolet. Each series consists of very many lines coming closer together toward high frequencies and finally converging to a definite limit. (Demonstration of the visible lines in the hydro-

gen spectrum.) A formula well describing the positions (frequencies) of these lines was discovered in 1885 by Balmer, a high-school teacher at Basel, Switzerland. This formula, $\nu = 3.29 \times 10^{15}(1/2^2 - 1/n^2)$, must be used as follows: introducing $n = 3$ you will obtain the frequency ν (vibrations per sec) of the first line, the conspicuous red line of this series; introducing the higher integers you will obtain the other lines, until finally approaching $n = \infty$ you will approach the finite limit $(3.29 \times 10^{15} \times 1/2^2)$ of the series.

TABLE 1.

Hypothesis	Formulae
(1) H atom: heavy nucleus, charge $+e$; orbital electron, charge $-e$, orbits defined by centrifugal force = Coulomb attraction	$ma\omega^2 = \dfrac{e^2}{a^2}$
(2) Only those orbits occur that in addition obey a *quantum rule:* angular momentum of electron $= n \times \dfrac{h}{2\pi}$ $(n = 1, 2, 3, \cdots)$	$ma^2\omega = \dfrac{nh}{2\pi}$ Conclusion: energy $W = -\dfrac{2\pi^2 me^4}{h^2}\dfrac{1}{n^2}$.
(3) *Radiation process:* Electron falls from outer to inner orbit; energy available is radiated. Its frequency is determined (not by the frequency of the orbital motion!) by the rule: $h\nu_{\text{rad}} = W' - W''$.	$\nu = \dfrac{1}{h}(W' - W'')$ $= 3.29 \times 10^{15}\left(\dfrac{1}{n''^2} - \dfrac{1}{n'^2}\right)$

In 1906 Lyman at Harvard discovered a similar series in the extreme ultraviolet, described as $\nu = 3.29 \times 10^{15}(1/1^2 - 1/n^2)$; $n = 2, 3, 4, \cdots$. Later still another series was discovered in the infrared $\nu = 3.29 \times 10^{15}(1/3^2 - 1/n^2)$; $n = 4, 5, 6, \cdots$. With the further development of spectroscopic technique, it was found that no other series exist for higher frequencies than the Lyman series but that on the low-frequency side, the infrared side of the spectrum, other such series can be observed. There-

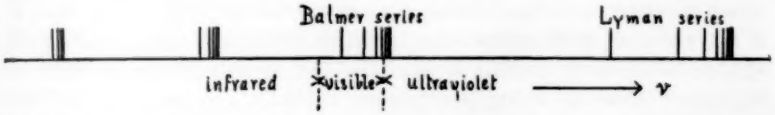

FIG. 1. Schematic representation of the spectrum of the hydrogen atom (not drawn to scale). Other series not given here are observed in the extreme infrared (to the left). This spectrum is compiled from observations with different types of instruments: glass or quartz spectrographs for Balmer series and near infrared, rocksalt spectrograph for the extreme infrared, vacuum grating spectrograph for the extreme ultraviolet (Lyman series).

fore the complete line spectrum of hydrogen is described by the *general formula* $\nu = 3.29 \times 10^{15}(1/n''^2 - 1/n'^2)$. For the Lyman series introduce $n'' = 1$; $n' = 2, 3, 4, \cdots$; for the Balmer series introduce $n'' = 2$; $n' = 3, 4, 5 \cdots$, etc.

The actual observation of the Lyman series is as difficult as the observation of the Balmer series is easy because of the fact that in the extreme ultraviolet the air is opaque as is glass and practically all crystals, as well as the gelatine of the photographic plate. Lyman used a vacuum-grating spectrograph and special photographic plates.

The aim of Bohr's theory is to set up a hypothesis as simple as possible from which the observed spectrum as given by the above formula can be derived.

II. Background of Bohr's Theory

(a) 1900. Planck, in his theory of black-body radiation, introduced the idea that an atom which is able to emit or absorb light of a certain frequency ν can exist only in states with "quantized" values of energy given as a multiple of $h\nu$; h is a universal constant ($= 6.61 \times 10^{-27}$ erg-sec).

(b) 1905. Einstein described the photoelectric effect (liberation of electrons from a metal surface by light) as follows: light of the frequency ν consists of quanta of energy $h\nu$ which may transfer their energy to an electron at the metal surface, so liberate it and, in addition, give it kinetic energy.

(c) 1911. Rutherford concluded from his experiments on the scattering of α particles when passing through metal foil that the mass of atoms does not fill a certain small space uniformly but that instead the mass of each atom is concentrated in a very small nucleus. The total size of the atom is given by the very light electrons forming a kind of planetary system; in order to explain that the electrons are kept near the nucleus, this is assumed to have a positive charge.

III. Bohr's Theory of the Hydrogen Atom (1913)

(a) *Planetary orbits*

The simplest possible shape of Rutherford's idea, as Bohr assumed it from the lightest atom, is one electron (charge e, mass m) circling about a nucleus which must carry the positive charge e attracting the electron and which is supposed to have a mass very heavy as compared to the mass m of the electron. Bohr accepts the condition for the stationary state as it applies to the earth circling around the sun: centrifugal force = force of attraction (Coulomb force) (formula see Table 1). This equation contains two variables a and ω; e and m are constants. The possible values of a and ω cover a *continuous* range.

(b) *Orbits selected by quantum conditions*

In order to explain the bright spectral lines which are observed, Bohr assumes that not all these values of a and ω are realized but that within the atom a certain quantum law restricts the orbits. This law is selected

by Bohr so that the observed spectrum can be derived. Possibly he was guided by the fact that Planck's constant h has the same dimension as an angular momentum (erg-sec = cm^2 gr sec^{-1}). Bohr's hypothesis is that only those orbits occur for which the angular momentum of the electron $ma^2 = nh/2\pi$ (n = quantum number = any integer, beginning with 1). This represents a second equation between the variables a and ω. Therefore, for a given quantum number n one can express the numerical values of a and ω. Furthermore, one can compute the energy of the circling electron, that is potential+kinetic energy (formula see Table). (The potential energy remains uncertain by an additive amount, because for its definition one must assume an arbitrary zero point, just as the potential energy of a stone in the laboratory is defined only after the choice of an arbitrary zero point; it is conventional to choose as zero the potential energy at an infinitely great distance in this way it happens that all values of potential energy and total energy come out negative. This will have no effect on the final result since only *differences* of energy will be applied which are not affected by the choice of the zero point.)

(*c*) *Radiation process*

When an electron goes in from an outer to an inner orbit and so energy becomes available, this energy is radiated and observable in the spectrograph as light of a certain frequency. From electrodynamics, we expect that an electron circling in an orbit, that is moving around with a definite frequency (number per sec), will emit light with this frequency. Bohr discards this idea. It is true, he argues, that electrodynamics is suitable for the description of all laboratory experiments, for example, the radiation from electric oscillators. But applying these laws to processes in the atom means a far-reaching extrapolation. We must not be surprised if it fails. Instead, Bohr applied Einstein's idea to the frequency ν emitted from the atom. That is, he assumed that this frequency represents a certain energy quantum $h\nu$ which is supplied by the energy difference between the quantized states of the atom. So he computes the frequency emitted, to be observed in the spectrograph:

$$\nu = \frac{1}{h}(W' - W'') = \frac{2\pi^2 me^4}{h^3}\left(\frac{1}{n''^2} - \frac{1}{n'^2}\right).$$

Any pair of different integers introduced for n'' and n' is supposed to lead to an observable frequency, that is, to a spectral line. Introducing the well-known figures for the universal constants e, m, h, Bohr finally obtained

$$\nu = 3.29 \times 10^{15}\left(\frac{1}{n''^2} - \frac{1}{n'^2}\right).$$

The striking agreement of this formula which is derived from the theory with the formula given under (1) describing observed spectral lines is the first proof for the validity of the theory. The red line of the Balmer series. for example, is described by Bohr as being emitted from atoms in which the electron falls from the orbit $n' = 3$ into the orbit $n'' = 2$, the higher

lines of the same series as being emitted from atoms in which the electron starts at a still higher orbit and ends at $n''=2$. The spectrum is excited in the electric discharge when *free* electrons or ions accelerated by the electric field (given by a transformer), collide with neutral atoms and knock the *bound* electrons of these atoms into higher orbits.

IV. Further Conclusions from Bohr's Theory

It must be admitted that Bohr's theory is built on such arbitrary fundamental assumptions that the striking agreement between his final formula and the experimental results cannot be considered as sufficient proof. Further proof can be obtained only by comparing other conclusions from the theory with the results of experiments. Here a wealth of results must be mentioned, concerned in particular, with the more refined investigations of the spectrum of hydrogen and the similar spectrum of ionized helium: the fine structure of all spectral lines, observed with spectrographs of high resolving power, the splitting up of all lines into narrow groups in magnetic or electric fields. On the other hand, Bohr's theory seems to fail for the more complicated atoms, beginning with neutral helium. Here great success is achieved by the more recent developments of "wave mechanics." Nevertheless, the amazing fertility of Bohr's theory in the fields of experimental and theoretical atomic physics makes it certain that this theory represents a great step forward toward a correct description of the processes in the atom.

Notation

ν = frequency of light (vibrations per sec)
h = Planck's constant $= 6.61 \times 10^{-27}$ erg $\times$ sec
n = an integer
m = mass of electron (g)
e = charge on electron (e. s. u.)
a = radius of orbit (cm)
ω = angular velocity (angle per sec)
W = energy of electron (kin. energy + pot. energy) (erg)
$'$ = upper level
$''$ = lower level

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THE NEW HARVARD CYCLOTRON—WHAT IT IS: HOW IT WORKS, AND WHAT IT IS TO BE USED FOR

(Notes from the talk by Dr. Roger W. Hickman)

Before discussing what a cyclotron is, how it works, and what it is to be

used for, I should like to mention a few of the central facts which have given rise to the need of such an instrument.

As Professor Oldenberg has just told you, the period from 1913 to approximately 1932 might be called the era of the spectroscopist. During this period large numbers of physicists were actively engaged in studying atomic spectra and correlating their observations with the beautiful Bohr-Rutherford nuclear atom model. They succeeded very well in establishing a working theory for most of the observed experimental facts which concern the outer electronic structure of the atom. The Cavendish laboratory under the direction of the late Lord Rutherford continued, however, to devote considerable time to problems concerned with the nucleus of the atom. Such problems included the detailed study of natural radioactivity and attempts to produce a transmutation of one element into another by using the high-speed energetic alpha particles as projectiles with which to bring about the desired transmutation. In 1919 Lord Rutherford was successful in transmuting nitrogen into a form of oxygen by bombarding nitrogen atoms with alpha particles from natural radio-active sources. From this key experiment was born the desire of scientists to have available, controlled sources of high-speed atomic particles with which to study the transmutation processes.

Before 1930 all the methods proposed for obtaining high-speed particles involved the production of high voltages which could then be applied to a suitable vacuum tube to accelerate positive ions. In September 1930, Professor E. O. Lawrence of the University of California at a meeting of the National Academy of Science proposed a method for obtaining high-speed particles without the necessity of producing a very high potential. In less than two years he showed that the method was practical and in fact accelerated protons to a velocity equivalent to that which would have been produced if a difference of potential of 1,200,000 volts had been available. With this statement the answer to the first section of the title becomes apparent—the cyclotron, as Lawrence's device was called, is simply a very ingenious piece of apparatus which may be used to obtain high-speed particles of atomic dimensions which can be used for a variety of purposes.

Before proceeding further with details concerning the cyclotron I should like to digress to point out that the year 1932 will probably go down in the history of physics as a very significant year. It marked the announcement of the first transmutation of one element into another using a laboratory controlled source of high-speed particles, the discovery of heavy hydrogen, the discovery of the neutron, the discovery of the positron, and definite confirmation of the utility of Professor Lawrence's ingenious method of obtaining a source of high velocity ions for further work in nuclear physics.

The explanation of how the cyclotron works may best be made with reference to Figure 1. A magnet, an acceleration chamber, a source of high frequency potential, and auxiliary power supplies constitute the main

parts of the cyclotron. The accelerating chamber, vacuum tight, is usually mounted in a horizontal plane between the pole pieces of a large electromagnet. Within this chamber and supported on glass insulating

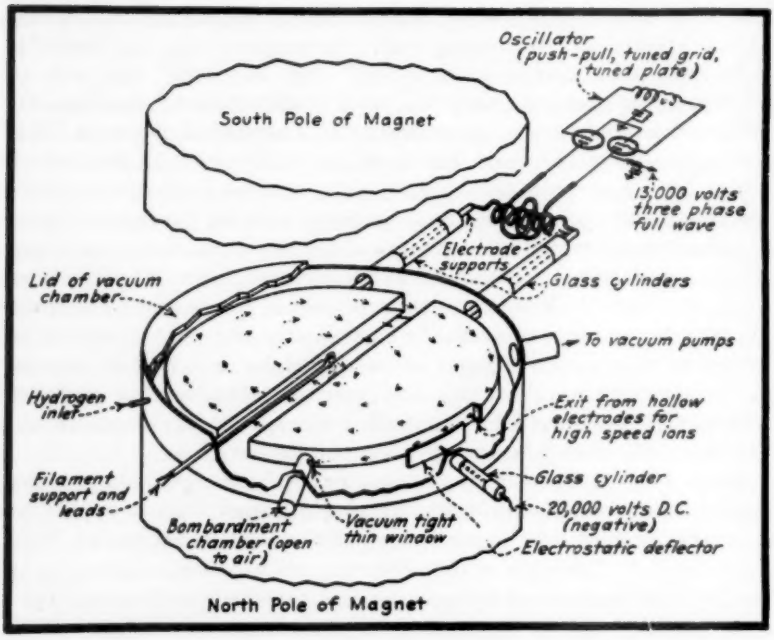

FIG. 1. A cut-away view of the acceleration chamber showing the relation of the magnetic field, acceleration electrodes, ion paths, and bombarded materials. Reproduced with the kind permission of *Electronics*.

supports are the hollow, water cooled, copper accelerating electrodes. Because of their shape these electrodes are frequently referred to as *dees*. In the center of the chamber, between the dees and slightly above their horizontal plane is mounted a filament which is used as a source of electrons. Symmetrically placed with respect to the filament and below the plane of the dees is a collecting plate which will have a positive potential with respect to the filament and which will act as a collector of the electrons emitted by the filament and travelling in a vertical plane. A small amount of hydrogen, heavy hydrogen or helium is usually introduced into the chamber. The electrons travelling from filament to collecting plate ionize some of the gas molecules and so produce positively charged ions in the central region of the chamber. If at any instant one of the dees has a high negative potential the positive ions will be accelerated toward that electrode, will pass into the hollow space in the dee and will then travel on an approximately circular path, its centripetal acceleration

being supplied by the magnetic field. If, when the ion has completed its semi-circular path and is ready to emerge from one dee the potential of the dees reverses, the other dee now becomes negative, and the ion will will again be accelerated across the gap between the dees, and the process repeated. Thus each time the ion crosses the gap between the dees it increases its velocity by an amount equal to that which the potential difference between the dees can impart to it.

The ion thus obtains two increments of velocity for every revolution which it makes and on each revolution it traverses a path of slightly greater radius than the previous one. When the ion reaches the periphery of the dee it passes through a narrow slit and has its course slightly altered from a circular path by a deflecting electrode which is charged to a high negative potential. The ion may then strike a sample of any material, acting as a target which may be introduced into its path.

The cyclotron was originally called a magnetic resonance accelerator. This is a very apt term when one considers that the crux of its whole operation depends on the equality of the time taken by the ion to traverse a semi-circular path and the time of alternation of the high frequency potential applied to the dees by the external oscillator. The simple equation describing the motion of the ion shows that the time of traversal of a semi-circular path is independent of both the radius of any particular path and the potential difference of the dees. This simple fact permits the ions to travel in synchronism with the alternations of the high frequency potential. The final energy of the particle is equal to that obtained from a single fall through the potential difference between the dees, multiplied by the number of times it crosses between the dees in its spiralling path.

Energies equivalent to that which might be obtained from d.c. voltages of approximately eight million volts have been obtained using alternating potentials of the order of only 50,000 volts. The cyclotron thus avoids the difficulties inherent in the problem of high voltage insulation.

Passing to the third aspect of the subject one may summarize briefly the primary uses of a cyclotron. The beams of high velocity ions are used to bombard various chemical elements. The transmutations which take place may produce new unstable nuclei, giving rise to artificial radioactivity, neutrons and gamma rays. The reactions which take place are of primary interest to the physicist and chemist as they furnish experimental evidence on which theories of nuclear structure may be built and confirmed. Certain reactions may serve as intense sources of neutrons whose properties are of interest not only to the physicist and chemist but also to the biologist and medical man. Unlike gamma rays and X-rays whose absorption is proportional to the density of the material traversed, neutrons are absorbed best by light materials, such as the hydrogenous tissue of the body. X- and gamma rays produce ionization in the tissue by means of the recoil electrons which are produced by the radiation. Neutrons on the other hand release recoil protons which are much more

effective as ionizing agents than are the electrons. This difference in the properties of X- and gamma rays and neutrons indicates that different biological action may be expected and there is already some evidence pointing to a greater selective action between healthy and diseased tissue by neutrons than is the case for X- and gamma rays.

In addition to the above there have already been produced approximately 220 artificially radioactive bodies, of which more than a hundred have a half life greater than two hours. This means that the chemist and biologist have at their disposal many new materials to use as indicators in chemical and biological studies.

The vastness of the field opened up by having available high speed ion sources such as the cyclotron is apparent when one considers that some scientists have spent practically their whole lives in studying the natural radioactivity of a very few materials, whereas it is now possible to produce from nearly every element an artificially radioactive substance. With only this meager outline in mind it appears that the coming era of physics will be known as the nuclear era.

In closing may I again remind you that the great stimulus which was given to nuclear physics by the late Lord Rutherford has been appropriately accelerated by the conception and achievement of the cyclotron by Professor E. O. Lawrence of the University of California. To the usefulness of his device no greater tribute can be paid than that at least twenty-five cyclotrons are either in operation or under construction in the leading physical research laboratories of the world.

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8. *Phys. Rev.*, *51*, 699 (1937) P. G. Kruger and G. K. Green. (Describes small Illinois installation.)
9. *Ref. of Sci. Inst.*, *9*, 1[0] (1938) M. C. Henderson and M. G. White. (Describes large Princeton installation.)

Book—Summary of Results obtained in Nuclear Physics

F. Rasetti, *Elements of Nuclear Physics*, Prentice Hall, Inc. 1936.

MEASURING NOISES IN EVERYDAY LIFE

PROFESSOR FREDERICK A. SAUNDERS

Measuring noises in everyday life. A noise, of course, is some kind of a sound that we do not happen to want or like. Noises come in great variety and some of them have very definite periodic properties. There may be a hum associated with them. Sounds such as the average traffic or typewriter noise are not traceably composed of periodical sounds, but a mixture of all kinds of sounds. Some noises, the hiss, for instance, contain such a mixture, but more of the energy in the very high frequency sounds. The effects of these different types of noises should be studied separately, but in general, noise does produce certain effects on people. We have unfortunately to live under very noisy conditions—increasingly noisy. I have heard that certain Harvard boys work best when the radio is going. The younger generation tolerate noise to a greater extent than many of us would find easy. We have a number of direct experimental evidences that noise is harmful.

Professor Laird, of Colgate University, induced some of his students to follow an experiment by means of which measurements could be made on the contractions of the stomach; these are associated with hunger and the process of digestion. Loud sounds had a definite effect upon them.

Experiments have been made upon sleep with the not very surprising result that one does not sleep so well under noisy conditions.

Experiments have been made upon the accuracy with which one works, with the accuracy with which telephone operators make connections, or stenographers write on their typewriters. There are other practical tests. There is found in general a loss of efficiency—maybe 10% or perhaps 30% in the presence of loud noises. These facts mean money to large commercial establishments. The question has been taken up seriously by a number of them with the result with which we are now familiar, that there are many places in which there is acoustical treatment.

To determine how harmful noise is, or to find how effective a treatment is, one has to measure the sound first, and for this one needs some kind of an instrument. I present an instrument, made by the General Radio Company, for your inspection; it is very good and very convenient. It is self-contained, including all its own batteries. It has a sensitivity scale which can be altered over a wide range. I can turn this button and you will soon note the motion of the pointer if you are favorably seated. You will see the needle being considerably agitated by my voice, and again agitated when it is set at a high sensitivity, even when I am not talking. In the sensitive condition it is recording sounds near 40 decibels in intensity. The audience, and also the ventilating system are not perfectly noiseless. We have in the room a ground noise level which has about this value. If we went into the sub-basement in the middle of the night we could get a lower level. If we went into the country where there were no trees with leaves to rustle and no wind, and no birds, we might get down

as low as 10; this requires exceptional circumstances. One can make measurements from such low levels to those of very loud sounds with the greatest of ease with this noise meter. (A chart was shown giving the intensities of sound in a variety of conditions.)

These measurements are made on the decibel scale, which has been in use for a number of years. It is mentioned in the book by Dr. Harvey Fletcher on *Speech and Hearing*, which I hope you all have available—dated 1929. As the subject of acoustics goes, that book is already somewhat out of date. The decibel is, of course, the tenth of the bel, and the bel is a logarithmic unit. The scale upon which we measure sound is a scale of ratios. We might count the sound we can barely hear as having a certain strength and measure everything in relation to it. We measure the strength by what we technically label the intensity of the sound, expressed in the number of ergs of acoustic energy which exist in one cubic centimeter.

This intensity varies enormously. The tablet in this room commemorates the work of Professor W. C. Sabine. He did some of the first measurements in this country on the intensity of sounds coming from organ pipes. Some of his pipes produced three billion times as much energy as the least which he could hear. The use of logarithms is very convenient in handling such large numbers. Hence the scale of bels or decibels. If the sound goes from 40 to 70 decibels and if this is measuring intensity as it is supposed to do, it means that you have an increase of 30 decibels or 3 bels, so the sound is 10^3 or one thousand times more intense than it was. This scale is very convenient. One can plot sounds in intensities directly upon logarithm paper, which amounts to much the same thing.

I said the decibel scale was composed of ratios. To make it quite definite, one does not take the ratio of the sound intensity to the intensity of the least audible sound, for that is a very variable quantity, but one takes the ratio to the sound produced when a certain definite quantity of energy is involved. The usual definition is that the intensity of a sound is the ratio in decibels, i.e. (on a logarithmic scale) to the intensity of the sound produced when the acoustical power flowing through an area of one square centimeter at the ear is 10^{-16} watts. This corresponds to the faintest sound you can hear if you have unusually good hearing.

Unfortunately we have some difficulties here, in this subject, especially, when we talk about loudness of sound. There have been a lot of experiments on estimating how loud a thing was, and I am afraid that neither you or I could accurately tell whether two sounds had a particular ratio of loudness or not. Nobody thought of any definite way of measuring loudness until Dr. Harvey Fletcher considered the physiological action in the course of hearing, and decided that two ears were better than one; and that if the use of one ear could give you a certain loudness the use of two would give you twice that loudness. The logarithm of the intensity of a sound, i.e., the intensity measured in decibels can easily be found. We now take a pure tone of a frequency of 1000 cycles per second as a stand-

ard, and call the intensity levels of this sound its "loudness levels." Then we compare the loudness of any pure tone at another frequency with the 1000 cycle tone and find the intensity of the latter which sounds equally loud. The particular intensity of the 1000 cycle tone which has the same loudness is called the loudness level of the other sound. Thus loudness-level curves can be plotted for all frequencies.

The assumption that the logarithm of the intensity of the 1000-cycle tone corresponded to its loudness (and could be called its loudness-level) is not quite right. Through Dr. Fletcher's use of two ears for one a loudness scale has now been made to compare against loudness levels. Thus we are now able to find the loudness of a pure tone if we know its intensity, and the same can also be done for most sounds that are complex.

The units in sound have been somewhat confused as the subject grew; in England they did not like the decibel particularly, and used it reluctantly. In Germany they invented a unit of their own which they called the "phon." The international usage became complicated, and a conference was held in the summer of 1937 at which a decision was reached giving us an international system of notation. Since last summer we have had to adopt the "phon" as a logarithmic unit of loudness-level, related to the decibel, but not the same. Some account of these things without mentioning the phon is found in the instruction book which comes with the sound meter.

We have a number of practical questions in which these units and these measurements are of value. There was, some years ago, a noise survey made of New York City. It was found that if you want to be quiet in New York City, the thing to do is to go up into one of the tallest buildings which have set-backs. These are the quietest spots in New York City. The idea of securing quiet by going up in the air is unfortunately not a correct one, because as you go up in the air you expose yourself to sound coming from a wider range than you did before, even though you are somewhat remoter from the nearest part of it. The net result is that the sound remains about the same above the city for several thousand feet up, excepting for the set-backs.

One wants to design a motor horn in such a way that it is audible above the street traffic. There is a phenomenon called masking of sound which prevents us from hearing certain sounds in the presence of others. The relation between loudness and masking forms the subject of a recent paper by Fletcher and Munson in which the measurement of loudness is developed. Reference to this may be found in the *Bell Laboratories Technical Journal* or in the *Journal of the Acoustical Society of America*—July, 1937. The masking of a motor horn by city traffic would be rather unfortunate. One needs to know how loud to make it so that it will surely be heard.

The study of quantitative measurements of noise is particularly important in things like trains, automobiles, and airplanes. I had the pleasure of being present at a meeting last November in the neighborhood of

Detroit, when there was a discussion of the quieting of automobiles. The automobile men were shy in giving to each other the secrets of their own companies. The result was that very little appeared in the discussion that was important. The net result to be gathered, however, was that if you kept your automobile shut you would then have a loudness-level of about 70 or 80 decibels, which is well up the scale, at a speed of sixty miles an hour. Opening a window, however, is strictly forbidden, because that introduces 10 or more decibels of wind noise.

The problem of the back seat driver came into this discussion because it was pointed out that against the noise-level of 70 or 80 "db's" the back seat person had to shout considerably to secure the attention of the front seat person. It works better to have the talker next to the front seat person. The stopping of noise from automobiles is in part dependent on the prevention of rattling from the panels. Much attention is paid to their natural resonant periods and tarry substances are put on their inside surfaces to stop noise due to vibration. Attention has also been given to exhaust and intake noises and there are some very pretty silencers available, produced by the Burgess Battery Company of Madison, Wis., and by others. In all these cases the sound meter is used to test the degree of improvement caused by alterations.

In airplanes you have a much more difficult job because of the limitations of weight. One line specialized on sound-quieting and got down to 85 or 90 decibels. Even so, that is about the loudest sound you find on a railway train; none too quiet.

I need not dwell at length upon the methods of quieting buildings.—We have as you see quieted this room with the use of acousti-celotex in the ceiling. In some of our hall-ways there is similar treatment. If there is a noisy person down the hall the noise gets killed on the way to you. If one cannot quiet an entire building, acoustical treatment along halls and in important rooms is simple to arrange and helps in protecting people from the harmful effects of noise.

NOTES ABOUT "CERTAIN RESEARCHES NOW IN PROGRESS" AT THE HARVARD PHYSICS LABORATORIES

The primary objects of the researches may be summarized as follows:

Both the *cyclotron* and the *Van de Graaff generator* are examples of important devices for obtaining high-speed atomic particles which will be used to bombard atoms of various chemical elements. The two devices are supplementary: The Van de Graaff generator has its main application where energies of the order of one million volts are desired, while the cyclotron can easily produce particles of much greater energy. The Van de Graaff generator of the size which has been built at Harvard is much less expensive than a cyclotron and has the additional advantage of producing a more homogeneous beam of high-speed particles. It is hoped that the disadvantage of the inhomogeneous ion beam produced by the cyclotron will be removed by the application of a magnetic device which will divide

up the high-speed ion beam into homogeneous parts. Transmutation of the elements, artificial radioactivity, and intense sources of neutrons are the chief results of the atomic bombardments, and these are of interest to the physicist, chemist, biologist, and medical man.

Professor Bainbridge's *mass spectrograph* is designed primarily for the accurate measurement of atomic masses, and the supplementary spectrograph of Dr. Nier determines the relative abundance of a particular atom in any given sample of material.

The *cosmic-ray research* carried on by Professor Street and Dr. Stevenson is directed toward determining the physical properties of cosmic rays and measuring their energy losses and their reactions with matter in passing through it. Recently this apparatus has yielded evidence pointing toward the existence of a new fundamental particle whose mass is apparently intermediate between that of the electron and the proton.

With the large *concave grating*, spectra are produced by the same process that is used for the spectra with the replica grating. The only difference is that in large concave gratings light is refracted from a mirror instead of being transmitted by a glass plate. The grating is ruled on a mirror; diffraction and interference produce the spectrum. The room itself is the dark chamber or camera.

With such gratings a wealth of experimental material has been collected on atomic spectra and molecular spectra and the changes by magnetic fields, electric fields, changes of temperature, etc. At present the grating is used for the investigation of chemical reactions in gases. The main idea is as follows: While the chemist has tests only for stable molecules like N_2, H_2O etc., he builds theories in which unstable molecules, that is, radicals like OH, NH, play an important part. We are trying to observe such radicals by their characteristic absorption spectra during the progress of a chemical reaction and so determine the elementary steps by which their reaction proceeds.

NOTES ABOUT "SOME USEFUL DEMONSTRATION APPARATUS"

Shown by ASSISTANT PROFESSOR N. HENRY BLACK

I. WORKING MODELS which are especially designed to show important apparatus or instruments on a very large scale.

(*1*) A *vacuum tube* magnified six times. This is, of course, shown here without the glass and is the three-element tube. It is arranged in such a way that a current can be sent through the filament so that it glows; the grid is shown as a spiral wire, and the plate which surrounds it is cut away in order to show the filament within.

(*2*) *D'Arsonval galvanometer*, magnified six times. This is built as nearly as possible like the typical commercial instrument manufactured by Weston, the General Electric Company, and others. It is, however, made so that the coil actually rotates, carrying the pointer along a scale which can be easily imagined in place.

(*3*) The principle of the *hot-wire ammeter* is illustrated by a piece of No. 24 Nichrome wire supported between two uprights about six feet apart. Here we can show the sagging when the wire is hot by attaching a small weight in the center of the wire. We can also measure the resistance

by the voltmeter-ammeter method. Knowing the temperature coefficient, one can easily calculate the temperature of the red-hot wire.

(*4*) A *Chevrolet engine* which has been cut away for demonstration purposes. This is, of course, not the latest model, but it serves to illustrate the principles of the internal-combustion engine. It is operated by a small motor and so illuminated that the student can see the different parts in motion.

II. DEMONSTRATION APPARATUS.

(*1*) *The Grimsehl apparatus for illustrating action and reaction.* This is familiar to most of you as the piece of apparatus consisting of a bicycle wheel mounted on a vertical axle with a toy train on the track around the rim. What we have done is to replace the spring-wound locomotive by an electrified locomotive and we have added a third rail. The connections are made through an annular cup of mercury attached to the spindle.

(*2*) *The Evans electrical equipment for demonstrating the rotating magnetic field*, with two-phase and three-phase current. In the original form of the apparatus, the field was produced by a circular iron frame with four or three coils arranged in this ring. It is rather easier from a teaching point of view, and it is usually so illustrated in the textbooks, to have the field made with re-entrant poles, and we have therefore rebuilt that part of the equipment, using the same rotators as before.

(*3*) *Projection apparatus for showing black absorption lines of metallic sodium.* Formerly we did this by sending white light from an arc lamp through a sodium flame produced by soaking asbestos sheets in salt water. By this method it was difficult to get a sodium flame intense enough to make the absorption line visible to a class of 150 men. Now we take the same arc lamp as our source of light, but use a Bunsen burner with a little boat made out of stainless stell to carry a bit of metallic sodium. This is placed inside a cylindrical chimney about the sodium film. The spectroscope is of the usual direct-vision type, which is easier to manage on an optical bench.

(*4*) Every physics teacher is familiar with the *optical disk* and blocks of glass used to show the action of converging and diverging lenses. Since we found that the optical disc was rather small for large divisions of students, we used our regular optical bench with an arc lamp and a large condenser. In front of this we set up a screen with several parallel slits to give us the parallel beams of light, and then placed large blocks of glass (six inches) across the beams to illustrate the converging and diverging lenses. No new principles are shown, but the old ones are demonstrated more clearly with this apparatus than with the old.

(*5*) All physics teachers have doubtless tried to demonstrate the *interference bands produced by soap films.* The trouble has usually been that when everything was ready to make the demonstration, the soap film broke. Some years ago the demonstrator at the Cavendish Laboratory showed me a device which, he said, overcame this difficulty. It is so simple

that I think anybody can very easily build one in his own shop. It consists of a small cubical box about 5 inches on a side, with a glass front slightly tilted to prevent reflection from the glass window. A small crystallizing dish containing the soap solution is placed in the bottom of the box. A ring which can rotate about an axis that is tangential to the ring is made so that it can be dipped into the soap solution and then brought to a vertical plane. With this the likelihood that the soap film will break at the critical moment seems to have been eliminated because the atmosphere inside the box soon becomes saturated, which lengthens the life of the film.

(*6*) My last demonstration is the *projection apparatus for showing the Wilson Cloud Chamber*. This I have already described in the December 1937 number of SCHOOL SCIENCE AND MATHEMATICS and therefore I shall simply show you the apparatus in operation.

USEFUL BOOKS FOR PHYSICS TEACHERS

(*More or less recent*)

General College Textbooks

Black, N. H., *An Introductory Course in College Physics*. The Macmillan Co.
Foley, A. L., *College Physics*—Revised. P. Blakiston's Son & Co.
Lemon, H. B., *From Galileo to Cosmic Rays*. University of Chicago Press.
Saunders, F. A., *A Survey of Physics*—Revised. Henry Holt & Co.
Stewart, O. M., *Physics Textbook for Colleges*—Revised. Ginn & Co.
Wold, P. I., *Kimball's College Physics*—Fifth edition. Henry Holt & Co.

Dictionaries, Handbooks and Tables

Glazebrook, R., *Dictionary of Applied Physics*. 5 vols. Macmillan & Co.
Kaye and Laby, *Physical and Chemical Constants*. Longmans, Green & Co.
Marks, L. S., *Mechanical Engineer's Handbook*. McGraw-Hill Book Co.
Fowle, F. F., *Standard Handbook for Electrical Engineers*. McGraw-Hill Book Co.
Hodgman's *Handbook of Chemistry and Physics*. Chemical Rubber Publishing Co.

Mechanics

Jameson, J. M., *Elementary Practical Mechanics*—Revised. John Wiley & Sons.
Gail, O. W., *Romping through Physics*. George Routledge & Sons, Ltd.
Fisk, Dorothy, *Exploring the Upper Atmosphere*. Oxford University Press.
Brooks, C. F., *Why the Weather?* Harcourt, Brace & Co.
Maguire, C. J., *Aerology*, McGraw-Hill Book Co.

Heat

Barton, A. W., *A Textbook on Heat*. Longmans, Green & Co.
Andrade, E. N. daC., *Engines*. G. Bell & Sons, Ltd.

Electricity

Timbie, W. H., *Elements of Electricity*—3d ed. John Wiley & Sons.
Pohl, R. W., *Physical Principles of Electricity and Magnetism*. Translated by W. M. Deans. Blackie & Son, Ltd.
DeVille, Eric, *Elements of Electrical Engineering*. Blackie & Son, Ltd.

Sound

Wood, Alexander, *Sound Waves and their Uses.* Blackie & Son, Ltd.
Miller, D. C., *Sound Waves, their Shape and Speed.* The Macmillan Co.
Watson, F. R., *Sound.* John Wiley & Sons, Inc.

Light

Bragg, Sir Wm., *The Universe of Light.* G. Bell & Sons.
Johnson, B. K., *Lecture Experiments in Optics.* Edw. Arnold & Co.
Michelson, A. A., *Studies in Optics.* University of Chicago Press.
Hardy & Perrin, *The Principles of Optics.* McGraw-Hill Book Co.

Modern Physics

Darrow, Karl K., *The Renaissance of Physics.* The Macmillan Co.
Millikan, R. A., *Electrons (+ and −), Protons, Photons, Neutrons, and Cosmic Rays.* University of Chicago Press.
Darwin, C. G., *The New Conception of Matter.* The Macmillan Co.

Historical

Magie, W. F., *A Source Book in Physics.* McGraw-Hill Book Co.
Chase, C. T., *A History of Experimental Physics.* D. Van Nostrand Co.
Lenard, Phillip, *Great Men of Science*—Translated by H. S. Hatfield. G. Bell & Sons, Ltd.

EXPERIMENTAL STUDY OF THE SOUNDS MADE BY INSECTS

Professor G. W. Pierce showed apparatus for measuring and recording the sounds made by insects. Parabolic horns were used for converging the sounds, and the receiving apparatus was capable of receiving from 2000 to 50,000 cycles or more.

Locating the insect by focusing the horn of a portable receiver in the direction of the sound, and following the sound, the insect is caught, identified as to species, a record of the sound and pictures of the insect are made.

Professor Pierce showed moving pictures in color of the insects in action, together with still pictures in color of the details of their sound-making apparatus.

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

NOTE. Persons sending in solutions and submitting problems for solution should observe the following instructions.

1 Drawings in India ink should be on a separate page from the solutions.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the one submitted in the best form will be used.

LATE SOLUTIONS

1533. *J. H. King, Corsica, Pa.*

1536. *Charles Eotes, Portland, Ore.*

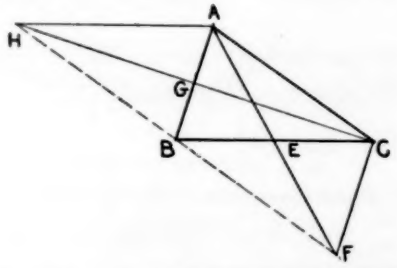
1539. *J. B. King, Corsica, Pa.*

1542. *Norman Anning, Univ. of Michigan, J. B. King, Corsica, Pa., R. L. Caskey, University of Oklahoma.*

1543. *R. L. Caskey, and J. B. King.*

1544. *Proposed by Chas. P. Louthan.*

In the triangle ABC the side BC is bisected at E and AB at G; AE is produced to F so that $EF = AE$ and CG is produced to H so that $GH = CG$. Prove that F, B, and H are collinear.



Solution by R. L. Caskey, Norman, Oklahoma.

Draw BH, AH, BF, and CF.

Since the diagonals of the quadrilateral $AHBC$ bisect one another the figure is a parallelogram. Hence, BH is parallel to AC.

Similarly $ABFC$ is a parallelogram and AC is parallel to BF.

Therefore, HBF is a straight line.

Solutions were also offered by Julius H. Hlavaty, N. Y. C., Joseph Strohl, Forest City, Ill., Walter R. Warne, N. Y. C., J. Byers King, Corsica, Pa., Malcolm Kirk, West Chester, Pa., Charles Lehmann, Brenham, Texas, Charles Seidel, Brenham, Texas, Jerald E. Jackson, Macomb, Ill., D. F. Wallace, D. L. MacKay, N. Y. C., V. C. Bailey, Emory, Va., David Rappaport, Chicago, Charles W. Trigg, Los Angeles, and Albert M. Sannes, Valley City, N. D.

1545. *Proposed by Roy Mackay, Portales, N. M.*

For any integer a, show that

$$f(a, x) = 1!2! \cdots (n-1)!\, n!\, x^{n(n+1)/2}$$

when
$$f(a, x) = \begin{vmatrix} 1 & 1 & \cdots & 1 \\ a & a+x & \cdots & a+nx \\ a^2 & (a+x)^2 & \cdots & (a+nx)^2 \\ \cdot & \cdot & & \cdot \\ \cdot & \cdot & & \cdot \\ a^n & (a+x)^n & \cdots & (a+nx)^n \end{vmatrix}.$$

Solution by Norman Anning, Ann Arbor, Michigan.

Let $f(a, x, n)$ be the symbol for the given determinant.

Beginning at the bottom row and working upward to the second row subtract, from each element, a times the element which stands above it. This changes the appearance but not the value. Consequently $f(a, x, n)$ is equal to

$$\begin{vmatrix} 1 & 1 & 1 & \cdots & 1 \\ 0 & x & 2x & \cdots & nx \\ 0 & x(a+x)' & 2x(a+2x)' & \cdots & nx(a+nx)' \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ 0 & x(a+x)^{n-1} & 2x(a+2x)^{n-1} & \cdots & nx(a+nx)^{n-1} \end{vmatrix}.$$

Inspection of this shows that

$$\begin{aligned} f(a, x, n) &= x \cdot 2x \cdot 3x \cdots nx \cdot f(a+x, x, n-1), \\ &= x^n(n!) f(a+x, x, n-1). \end{aligned} \tag{1}$$

Similarly,

$$f(a+x, x, n-1) = x^{n-1}\{(n-1)!\} f(a+2x, x, n-2); \text{ and so on.} \tag{2}$$

$$\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots$$

$$f(a+nx-2x, x, 2) = x^2(2!) f(a+nx-x, x, 1). \tag{n}$$

And from the definition we have by expansion

$$f(a+nx-x, x, 1) = \begin{vmatrix} 1 & 1 \\ a+nx-x & a+nx \end{vmatrix} = x^1(!).$$

The required result follows from the multiplication of these n equations:

$$f(a, x, n) = x^{n(n+1)/2}(1!)(2!)(3!) \cdots (n!). \qquad \text{Q.E.D.}$$

Note that the value is independent of a.

EDITOR'S NOTE: This determinant is a special case of what is known as the determinant of Vandermonde. See Dickson, *First Course in Theory of Equations*, p. 108.

Solutions were also offered by John O. Chellevold, Waverly, Iowa, J. Gordon Deutsch, N. Y. C., Aaron Buchman, Buffalo, N. Y., and the proposer.

1546. *Proposed by William H. Taylor, Port Arthur, Texas.*

Show that a triangle may be constructed, given two sides and the median to the third side.

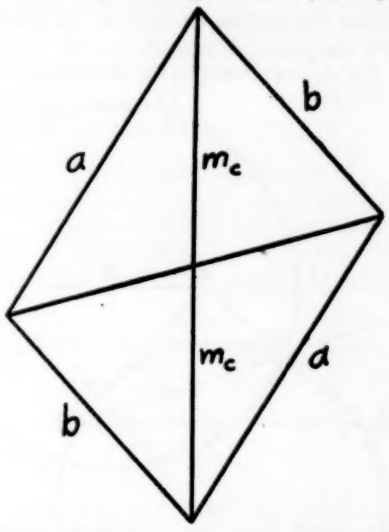
Solution offered by James Lyle, Lodi, Wisconsin.

Given: Segments a, b, and median m_c.

Construct triangle ABC using m_c as the median and a and b as the other given sides.

Construct the parallelogram with a and b as sides and $2m_c$ as diagonal.

Call it $ABCD$. Join A and C. Triangle ABC is the required triangle.



Other solutions were offered by J. B. Strohl, Forest City, Ill., Julius H. Hlavaty, N. Y. C., Walter R. Warne, N. Y. C., V. C. Bailey, Emory, Va., Jerald E. Jackson, Macomb, Ill., L. L. Ramsey, Lodi, Wisconsin, R. L. Caskey, Norman, Okla., Charles W. Trigg, Los Angeles, D. F. Wallace, and the proposer.

1547. *Proposed by Charles W. Trigg, Los Angeles Junior College.*

Find a set of eight distinct digits such that each of two different permutations there of may be factored into three consecutive integers. Show that there are no others.

Solution by the Proposer.

$(M-1)M(M+1=M^3-M=N$. Now $10234567 \leqq N \leqq 98765432$, so $216 \leqq M \leqq 464$. With the aid of a table of cubes, the values of M^3-M are examined for values of M within this range, and all which contain duplicate digits are discarded. Thus the only eight-digit numbers which are the products of three consecutive integers are found to be:

N	M
19682730	270
36925704	333
39651480	341
78953160	429
93576210	454
54871620	380
68417520	409

The last two recorded values of N are permutations of the same set of digits, which is the required one.

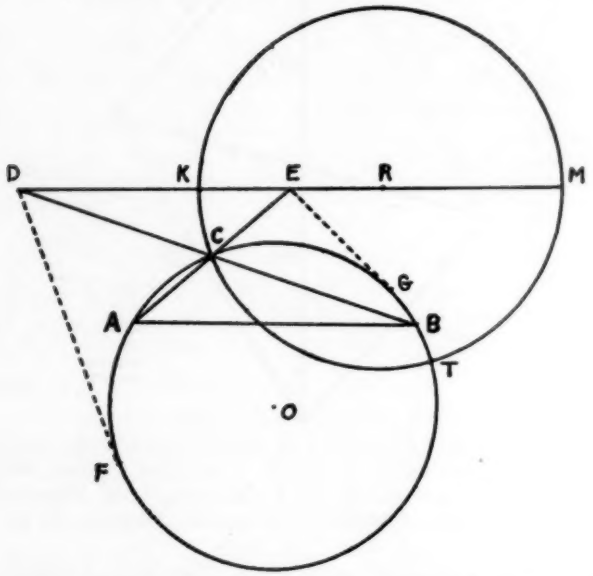
1548. *Proposed by Hobson M. Zerbe, Wilkes-Barre, Pa.*

In a given circle, inscribe a triangle so that one side shall be parallel to a given line and the prolongations of the other two sides of the triangle shall pass through the extremities of the given line.

Solution by Aaron Buchman, Buffalo, N. Y.

Let DE be the given line and let circle O be the given circle.

Draw DF and EG tangent to Circle O. On DE locate point K so that $DK:KE = DF:EG$. On DE extended locate M so that $DM:ME = DF:EG$.



Construct circle R upon KM as diameter. Let circle R intersect circle O at C and T. Through C draw secants DCB and ECA. Draw AB. ΔABC is the required triangle. Another solution is obtained by using point T instead of point C.

Proof

$$\frac{DF}{EG}=\frac{DK}{KE}=\frac{DM}{ME}$$

$\therefore$ circle R is the locus of points, the ratio of whose distances from D and E is DF/EG (circle of Apollonius, see any higher geometry text).

$$\therefore \quad \frac{DC}{EC}=\frac{DF}{EG}. \tag{1}$$

But $(DB)\,(DC)=\overline{DF^2}$ and $(EA)\,(EC)=\overline{EG^2}$

$$\therefore \quad \frac{(DB)(DC)}{(EA)(EC)}=\frac{\overline{DF^2}}{\overline{EG^2}}. \tag{2}$$

Dividing (2) by (1)

$$\frac{DB}{EA}=\frac{DF}{EG} \quad \text{and} \quad \frac{DB}{EA}=\frac{DC}{EC} \quad \text{(from (1))}$$

$$\therefore \quad \frac{DB-DC}{EA-EC}=\frac{DC}{EC} \quad \text{or} \quad \frac{CB}{CA}=\frac{DC}{EC}$$

and $\Delta DCE \sim \Delta ACB$

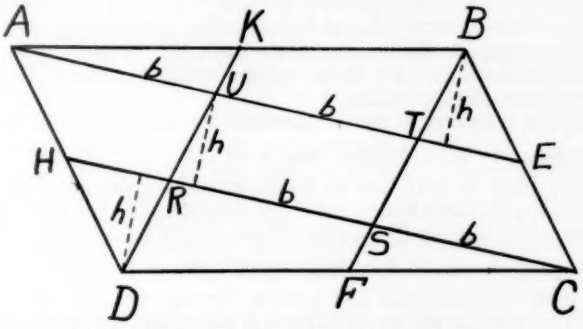
$$\therefore \quad AB \| DE.$$

A similar proof follows if we use point T.

Solutions were also offered by D. F. Wallace, Charles W. Trigg, Los Angeles, D. L. MacKay, New York City.

1549. *Proposed by O. T. Snodgrass, Yankton, S. D.*

In the parallelogram $ABCD$, E, F, H, K are midpoints of the sides BC, CD, DA and AB respectively. If DK meets AE and CH respectively in U and R, and if BF meets AE and CH in T and S, prove that $RSTU$ is a parallelogram and equal in area to $\frac{1}{5}$ parallelogram $ABCD$.



Solution by David Rappaport, Chicago, Illinois.

Since EC is parallel to and equals AH, $AECH$ is a parallelogram and AE is parallel to HC, In like manner KD is seen to be parallel to BF. Hence $RSTU$ is a parallelogram

Since $AH = \frac{1}{2}\ AD$, area of $AECH = \frac{1}{2}$ area of $ABCD$ (1)

In parallelogram $AECH$ the following relations can be established:

$$CS = RS \tag{2}$$

$$AU = UT = RS \tag{3}$$

$$HR = \tfrac{1}{2}AU = \tfrac{1}{2}RS \tag{4}$$

Hence $RS = 2/5HC.$ (5)

Hence area of $RSTU = 2/5$ area of $AECH.$ (6)

By substituting (6) in (1)

area $RSTU = 2/5 \times \frac{1}{2}$ area $ABCD$

or area $RSTU = \frac{1}{5}$ area $ABCD.$

Other solutions were offered by D. L. MacKay, New York City, V. C. Bailey, Emory, Va., Charles W. Trigg, Los Angeles, Julius H. Hlavaty, New York City, H. G. Ayre, Macomb, Ill., J. Byers King, Corsica, Pa., Walter R. Warne, New York City, D. F. Wallace, and R. L. Caskey, Norman, Okla.

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

For this issue the Honor Roll appears below:

1543. *Terry McCarty, Howard Spoeneman and Pearce Butterfield, from Brule High School, Nebraska; Eleanor Semiot, Sylvia Hershlag and Daniel Leorne from Evander Childs H. S., N. Y. C.; Dorothy Hardcastle, Priscilla Damon and David M. Colman, Scituate, Mass.*

1546. *Harry Chapin, Eli Perry, Simon Gratz H. S., Philadelphia; Dorothy Hardcastle and Cecil Leith, Scituate, Mass. H. S.*

1549. *Austin Detweiler, U. S. Coaching School, Columbia; Harold Rinker and Phillip Marshall, Perry H. S., Ia.; John Driscoll, Scituate, Mass.*

PROBLEMS FOR SOLUTION

1562. *Proposed by Joseph Bena, Leetsdale, Pa.*

A sphere with diameter of one foot is rolled into the corner of a room so as to be tangent to the floor and two walls.

a. Find the diameter of a larger sphere which is tangent to the given sphere, the floor and two walls.

b. Find the diameter of the smaller (inner) sphere tangent as in (a).

1563. *Proposed by W. R. Warne, New York City.*

A square tract of land has as many acres as there are boards in the fence enclosing it. Each board is 11 feet long and the fence is four boards high. How many acres in the square? (From Milne's *Standard Arithmetic.*)

1564. *Proposed by Charles W. Trigg, Los Angeles.*

From three stations on a line passing through the foot of a tower the angles of elevation of the top of the tower are taken. At the middle station the angle is the complement of the angle at the station 40 feet farther from the tower, which angle is one-half the angle from the station 20 feet closer to the tower than the middle station. How high is the tower?

1565. *Proposed by Cecil B. Read, University of Wichita, Kansas.*

If x lies between 0 and π, show that $\cot x/4 - \cot x$ is greater than 2.

1566. *Proposed. by Walter R. Warne, New York.*

Solve for x,

$$\sum \frac{b+c}{x-a} = 3.$$

1567. *Proposed by Aaron Buchman, Buffalo, N. Y.*

If OX and OY are two perpendicular rays; A and B, two fixed points on OX; P, a variable point on OY; without the use of calculus, find the position of P which makes $\angle APB$ a maximum.

SCIENCE QUESTIONS

June, 1938

Conducted by Franklin T. Jones

To Readers of School Science and Mathematics:

You are invited to propose questions for solution or discussion.

Send in answers to questions.

Examination papers are always desired, send in your own papers or any others. Tests and new things are wanted.

Please address all communications to Franklin T. Jones, 10109 Wilbur Avenue, S. E., Cleveland, Ohio.

JOIN THE GQRA (Guild of Question Raisers and Answerers). More than 230 are already members. Teachers, pupils, classes, and individuals may become members by submitting questions or answers.

"MADAME CURIE"

842. *Proposed by Adrien Aitken (Elected to the GQRA No. 232), Tamalpais Union High School, Sausalita, California.*

"I am enclosing a list of questions which may interest you and perhaps you will want to publish them in SCHOOL SCIENCE AND MATHEMATICS.

"As you will note the enclosed mimeographed sheets concern the life of Madame Curie. They are taken from the recently published book on the life of Madame Curie by her daughter Eve Curie. (Doubleday, Doran and Co., Garden City, N. Y.) The reading of this book and the answer to the questions is now a requirement of every student in the department of physics in our school. So far the students have taken kindly to the assignment and the results seem to be excellent."

"MADAME CURIE"

1. When and where was Madame Curie born?
2. List the various pet names given to Manya. Also give the names of the other members of the family.
3. Tell of Manya's learning to read.
4. Describe the work room in the home of the Sklodowskas.
5. In what way did the Russian school inspectors humilitate the Polish children?
6. What amusement did Bronya, Hela and the boarders have at the expense of Manya's gift of absorption?
7. What do you think of Manya's reply "That's Stupid"?
8. Explain the game called "Green."
9. How did patriotic Poles compliment the monument?
10. In what year did Manya finish her secondary studies? Discuss briefly her doings for the year following.
11. Why did Manya decide to be a governess?
12. As a governess did Manya abandon her studies? Discuss.
13. How many years did Manya spend as a governess?
14. Who was Casimir Z and what effect did he have on the life of Manya?
15. Explain carefully 66 Krakovsky Boulevard and its effect on the decisions of Manya.
16. In what year did Marie enter Sorbonne?
17. What is Sorbonne?
18. Ignace Paderewski is internationally known for what reasons?
19. Why did Marie leave her sister's home?
20. Give the causes for Marie's illness.
21. In what year did Marie pass her examination for the Master's degree in Physics? In Mathematics?
22. How did Marie get the 600 rubles?
23. Describe the first meeting of Pierre and Marie.
24. Give a brief description of Pierre.
25. What discoveries had Pierre already made in the field of Physics?
26. Why did Marie hesitate so long before she said "Yes" to Pierre's proposal of marriage?
27. Comment on the simplicity of the marriage of Marie and Pierre.
28. How was their honeymoon spent?
29. What effect did the Dreyfus case have on Pierre?
30. Describe Marie's efforts to become a successful cook.

31. What had Marie accomplished by the end of 1897?
32. Discuss the influence of Becquerel's discovery on the Curies.
33. Tell of Marie's first laboratory in her search for radium.
34. Why did Marie abandon uranium and undertake an examination of all chemical bodies?
35. How much did Marie accomplish before Pierre actually joined the search for the unknown element?
36. What progress was reported by July 1898?
37. What was reported in the proceedings of the session of Dec. 26, 1898?
38. How did the scientific world receive the discoveries of the Curies?
39. Describe the arrival of the pitchblende.
40. When was the atomic weight of radium determined?
41. What did the Curies discover in their visit to the shed after dark?
42. Write a short paragraph concerning the experiments which led to the use of radium in the treatment of cancer.
43. Why did the Curies refuse to patent the method of purifying radium ores? Would you have done the same thing?
44. What did the Curies do with the Nobel Prize money?
45. Describe the journalist's visit with Madame Curie at Le Pouldu.
46. When did the Curies move their apparatus from the old shed?
47. Outline the events of April 19, 1906.
48. Describe the first lecture given by a woman at the Sorbonne.
49. What do you think of Marie's school for Irene and the children of friends?
50. How was Madame Curie honored in 1911?
51. Give the location of Marie's new laboratory.
52. In what way did Madame Curie assist France during the World War?
53. Explain Port Science.
54. What famous physicist enjoyed hiking with the Curies?
55. Who was Mrs. Meloney?
56. What became of the gram of radium given to Madame Curie by the women of America?
57. In what respects did Madame Curie admire America?
58. How did America change Madame Curie?
59. At Geneva what did Marie try to accomplish?
60. Discuss Marie's visit to Madrid in 1933.
61. For what reason did Marie visit America for the second time?
62. What was the last work that Marie accomplished before death?
63. Give the immediate causes of Madame Curie's death.
64. Give the year of birth and death of Madame Curie.
65. In about one hundred words summarize what true greatness consisted of in the personality of Marie Sklodowska Curie.

ANSWERS

Excellent answers were submitted by Mr. Aitken (GQRA No. 232) to the above questions on "Madame Curie" by his pupils who are elected to the GQRA:

233. *Jean Paddock, Mill Valley, Calif.*

234. *Mary Peterson, Mill Valley, Calif.*

HEAT—EXAMINATION QUESTIONS

843. *Submitted by Leo R. Spogen (GQRA No. 64), Red Lodge, Montana.*

HEAT PART I (value 75 points)

1. The heat of fusion of ice is _____.
2. The heat of vaporization of water is _____.
3. The specific heat of water is _____.
4. To raise 100 grams of water from 10°C. to 25°C. would take _____ of heat.
5. To melt 50 grams of ice and heat the water to 10°C. would take _____.
6. 20°C. would equal _____ Kelvin.
7. The linear coefficient of expansion of iron is .000011. How much longer would a 1000 ft. bridge be if the temperature increased 100 degrees? _____.
8. Change 30°C. to Fahrenheit. _____.
9. A compound bar depends upon that fact that _____.
10. 100 cc. of gas at 0°C. and 700 mm. would occupy what space at 10°C. and 600 mm.? _____.
11. Would a red hot iron cool quicker on asbestos or on steel? _____.
12. What makes feathers such a poor conductor of heat? _____.
13. Why do people wear white instead of black in the tropics? _____.
14. _____ could be demonstrated with a piece of ice, a thread, and two weights.
15. Why does an inch of sawdust give better protection against heat than an inch board? _____.
16. The walls of a vacuum bottle are silvered in order _____.
17. Why is a copper washtub better to heat water in than an asbestos tub? _____.
18. By what method of heat transfer does heat from the sun pass through windows? _____.
19. Is it a good idea to wrap the ice in a refrigerator with newspapers? Why? _____.
20. When air is cooled to the dew point, its relative humidity is _____.
21. The instrument used to tell relative humidity is called _____.
22. Down to 4°C. a pond cools off by _____ below 4°C. it cools down by _____.
23. The operation of a thermometer depends upon what physical principle? _____.

24. An increase of millimeters of pressure near the boiling point of water increases the boiling point 1°C. _____.
25. In the last analysis I would say that heat was _____.

HEAT PART II (value 25 points)

1. How would you demonstrate that water is a poor conductor of heat?
2. If 50 grams of aluminum at 88°C. is dropped into 40 grams of alcohol at 14°C., the resulting temperature is 36°C. Find the specific heat of alcohol. Aluminum has specific heat of .22.
3. How much ice would 100 grams of water at 80°C. melt?
4. Explain artificial refrigeration.
5. How much heat will it take to convert 1 kilogram of ice at 0°C. into steam at 100°C.?

WHAT IS NEW?

Submitted by Virginia Gardner, Mercy High School, Milwaukee, Wis.
(Elected to the GQRA No. 235)

"I am a member of the Mercy Bio-ite Club and am writing to tell you of the conservation program given in accordance with the wish of President Roosevelt at Mercy High School during Conservation Week. The program that is enclosed with this letter was presented to the entire student body on March 21. One of the features on the program was an original poem written by Patricia Coles, the general President, a member of the GQRA (No. 209). Because of its fine conservation points, I have enclosed it hoping, if space permits, that you will see fit to publish it.

Another thing the biology students have done was to make bird houses, baths and even a bird feeding trough. They were sent to the Milwaukee Museum to be on exhibition during this week.

I would like to take this opportunity to thank you for the interest you have shown in our Club."

[*The poem by Patricia Coles (GQRA No. 209) is fine and I regret that lack of space prevents publication.* EDITOR.]

CONSERVATION PROGRAM, MERCY HIGH SCHOOL, MARCH 21, 1938

1. Opening Address, General President, Patricia Coles.
2. Opening Chorus, All M. B. C. Members.
3. Aggregate Value of Birds, Dorothy Grabarczyk.
4. A Skit, Details by Mary McCorry, Enacted by Seventh Period Class.
5. An Original Poem, Patricia Coles.
   "They have Feelings, Too."
6. A Skit, Written by Helen Raskiewicz, Enacted by Virginia Gardner and Genevieve Voelz of the Fifth Period.
7. Birds, Rita Regent.
8. Closing Song, All M. B. C. Members.
   (Parody on The Star Spangled Banner.)

HOW FAST?

839. *From a Newspaper Clipping.*

What is the fastest living creature?
How fast can it travel?

DEERFLY'S "REP" IS RUINED BY SCIENCE

New York, March 10.—(AP)—The speed of the deerfly—which scientists have called the fastest thing alive—was reduced from its 800-mile-an-hour record to a mere 26 today in experiments announced in Science by Dr. Irving Langmuir.

Dr. Langmuir went into his laboratory and made imitation deerflies which flew with precision equal to that of his chemical experiments which won him the $50,000 Nobel prize.

The wind pressure against the fly at 800 miles an hour, he found, would be eighty pounds a square inch, probably enough to crush the insect. It would have to burn up 1.5 its weight every second to produce the energy needed.

At 26 miles an hour, the Nobel winner reports, the laboratory flies were "merely a blur." At 64 they were invisible. This leaves the highest living speed record at present to the eagle, with about 180 miles an hour actually measured during a sweep.

SCIENCE NOTE TO TED ROBINSON, COLUMNIST

Dear Ted—

I am interested in mention of the speed of the deer-bot fly as reported by Dr. Charles H. T. Townsend and in Dr. Irving Langmuir's hypothesis on the impossibility of such speed in an animate organism.

The other day, I climbed a ladder to clean out an old wren house for the prospective tenants of the season. I found by reflecting light into the house that it contained wasps' nests. Poking in with a stick, I crumbled the nests. Then I struck a match and held it inside the house where it smudged and filled the chamber with smoke.

Suddenly two wasps streaked past my ear, going at a rate that put the deer-bot fly in reverse. I would be claiming the speed record for those wasps if it wern't for one thing. I hate to brag and I know that theoretically a body falls at the rate of sixteen feet the first second and accelerates at the rate of 32 feet each successive second, but when I came down that ladder the wasps' glory was short-lived.

Townsend and Langmuir to the contrary, I would have crushed any deer-bot or wasp that got in my way.

Vernally yours,
THE SEA COOK

RAINFALL GAUGE

830. *Proposed by L. M. Hollingsworth, San Diego, Calif. (GQRA No. 216)*

"If a tall, slender, thin-rimmed top can were placed perpendicular (vertical) to catch rainfall, why would it undermeasure?"

Answer by Kenneth P. Kidd (GQRA No. 131) Tallahassee, Fla.

Theoretically a tall can whose top is equal to its bottom will undermeasure because the sides of the can should diverge as the rays from center of earth through the edge of the bottom diverge as they extend outward from earth. Also, the sides of the can would cause the amount of rain falling into top to decrease before the rain reached the bottom by causing some to evaporate from surface of the sides and by holding back some of the water due to its adhesion to the sides.

PRESSURE IN AUTO TIRES

831. *Proposed by W. R. Smith (GQRA No. 176) Chicago, Ill.*

"When an automobile weighing 3000 lbs. is jacked up off the wheels, the air pressure in the tires is 30 lbs. (per sq. in.). If the car is then allowed to rest on the tires, will the pressure in them be altered? If so, why?"

Answer by Kenneth P. Kidd (GQRA No. 131) Tallahassee, Fla.

The pressure will be increased because the weight of the car tends to decrease the volume of air in tube. The pressure of a gas is inversely proportioned to its volume. The change in volume, in turn, depends upon the weight of the car, and the size of tire, and, to some extent, the pliability of the tire.

GQRA OUTING AT PEN' BRYN-ON-LAKE ERIE

On July 31, 1938, (Sunday) all members and their friends of the Guild of Question Raisers and Answerers are invited to meet at PEN' BRYN with the EDITOR OF SCIENCE QUESTIONS. PURPOSE: an exchange of ideas and the promotion of acquaintanceship. Come!!!

This probably is the only notice that can be sent this year. Please mark the date and try to reach Geneva on July 31st.

Please write the Editor a letter for the occasion. Address: Franklin T. Jones, Pen' Bryn, RD1, Box 241. Geneva, Ohio.

(Tourists via US Route 20 pass thru both Cleveland and Geneva. Stop and call on The EDITOR!)

BOOKS AND PAMPHLETS RECEIVED

Freshman Mathematics, by Hermon L. Slobin, Professor of Mathematics, and Walter E. Wilbur, Associate Professor of Mathematics, The University of New Hampshire. Revised Edition. Cloth. Pages xx+584. 13×20 cm. 1938. Farrar and Rinehart, Inc., 504 W. 26th Street, New York, N. Y. Price $3.50.

Our Physical World, by Charles F. Eckels, Chalmer B. Shaver, and Bailey W. Howard of the Department of Physical Science, Pasadena Junior College, Pasadena, California. Cloth. Pages xi+801. 13.5×20.5 cm. 1938. Benj. H. Sanborn and Company, 131 Clarendon Street, Boston, Mass. Price $2.20.

Van Nostrand's Scientific Encyclopedia. Cloth. 1234 pages. 185×26.5 cm. 1938. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York, N. Y. Price $10.00.

Qualitative Chemical Analysis, by Louis J. Curtman, Professor of Chemistry, In Charge of the Division of Qualitative Analysis, The College of the City of New York. Revised Edition. Cloth. Pages xii+514. 14×21.5 cm. 1938. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $3.75.

Trigonometry, by A. R. Crathorne, University of Illinois, and the Late E. B. Lytle. Revised Edition. Cloth. Pages ix+191+xvi+95. 14×21.5 cm. 1938. Henry Holt and Company, 257 Fourth Avenue, New York, N. Y. Price $2.00 with Tables and $1.70 without Tables.

American Wings, Modern Aviation for Everyone, by Captain Burr Leyson. Cloth. 214 pages. 14×20.5 cm. 1938. E. P. Dutton and Company, Inc., 300 Fourth Avenue, New York, N. Y. Price $2.00.

An Introduction to Business Statistics, by John R. Stockton, Associate Professor of Business Statistics, The University of Texas. Cloth. Pages v+378. 14.5×22 cm. 1938. D. C. Heath and Company, 285 Columbus Avenue, Boston, Mass. Price $3.00.

Earth Science, by Gustav L. Fletcher, based on New Physiography, by Albert L. Arey, Frank L. Bryant, William W. Clendenin, and William T. Morrey. Cloth. Pages v+568. 14×20.5 cm. 1938. D. C. Heath and Company, 285 Columbus Avenue, Boston, Mass. Price $2.20.

Sprinkle's Conversion Formulas, by Leland W. Sprinkle. Cloth. Pages xii+122. 10×16.5 cm. 1938. P. Blakiston's Son and Company, Inc., 1012 Walnut Street, Philadelphia, Pa. Price $1.25.

An Outline of Physics, by Albert Edward Caswell, Professor of Physics, University of Oregon. Revised Edition. Cloth. Pages ix+590. 14×21.5 cm. 1938. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $3.75.

Today's Geometry, by David Reichgott, and Lee R. Spiller, The New Haven High School, New Haven, Connecticut. Cloth. Pages xvi+279. 14×23 cm. 1938. Prentice-Hall, Inc., 70 Fifth Avenue, New York, N. Y. Price $1.84.

Portraits of Eminent Mathematicians with Brief Biographical Sketches, by David Eugene Smith, Professor Emeritus of Mathematics, Columbia University. Portfolio II. 25×34.5 cm. 1938. Scripta Mathematica, Yeshiva College, New York, N. Y. Price $3.00.

Myers-Ruch High School Progress Test, by Professor Charles Everett Myers, Supervisor of Research, Virginia State Board of Education; Professor Giles M. Ruch, Co-author of New Stanford Achievement Test; and Professor Graham C. Loofbourow, Principal of Lincoln School, Fresno, California. Form A, 8 pages. 25 Tests per Package with Manual of Directions, Key, and Class Record. World Book Company, 2126 Prairie Avenue, Chicago, Ill. Price per Package, net $1.30.

Farmers' Purchasing Associations in Wisconsin, by Rudolph K. Froker, Associate Professor, Department of Agricultural Economics, University of Wisconsin, and Joseph G. Knapp, Principal Agricultural Economist, Cooperative Division, Farm Credit Administration. Paper. Pages iv+118. 14.5×23.5 cm. Bulletin No. 20. October 1937. Copies may be obtained from the Director of Information and Extension, Farm Credit Administration, Washington, D. C. Price 15 cents.

Kilander Health Knowledge Test for High School Seniors and College Freshmen, by Holger Frederick Kilander, Dean and Professor of Health Education, Panzer College of Physical Education and Hygiene, East Orange, New Jersey. 8 pages. 21.5×27.5 cm. 1936.

Introducing The Slide Rule, by R. D. Black, and Mary M'Cord, Instructors in Physical Science and Mathematics, Wabash High School, Wabash, Indiana. Paper. 31 pages. 16×23 cm. Laboratory Specialties Company, 130 South Wabash Street, Wabash, Ind. Price 30 cents.

BOOK REVIEWS

Science in Our Lives, by Benjamin C. Gruenberg, Lecturer on the Philosophy of Science, College of the City of New York, and Samuel P. Unzicker, Formerly Vice-Principal, Roosevelt Junior High School, Fond du Lac, Wisconsin, and Lecturer on Secondary Education, Northwestern University, Evanston, Illinois. Cloth. Pages xiv+750. 13×19 cm. 1938. World Book Company, Yonkers-on-Hudson, New York, N. Y. Price $1.76.

This general science text, for use in the early years of the secondary school, contains the customary units of work. It is written to conform with various courses of study, and the recommendations of curriculum committees.

The eight units include topics on the following subjects: Air, Water,

Fire, Earth, Machines, Electricity, Biology, and Sound and Light. Each of these units is further divided into from two to five problems which, the authors state, have meaning for the young reader, either arising from prior experience, or induced by the preceding activities and discussions. Additional problems, not listed in the contents are found throughout the book.

The text contains over four hundred illustrations, and at the ends of the chapters are lists of over three hundred experiments and activities common to general science books. All forms of tests are omitted in the text. The authors suggest the use of another World Book Co. publication, Glen and Gruenberg's "Instructional Tests in General Science."

The authors state in the preface, "We have attempted to make clear the distinction between facts or phenomena and the theories designed to explain them." On page 7 the authors state, "We ought to make doubly sure about all our facts before we utter a general statement about any group or class of things."

Although the authors have been rather consistent in these aims, a few instances in which they were not consistent were noted. For example: on page 578, "Yet we feel sure that the millions of animals of the thousands of different species that are living at any moment *all started life as eggs*. And we are equally certain that each egg came from the body of a similar animal the mother."

On page 355, "Chemists have succeeded in producing new compounds that do not exist in nature." This statement assumes that chemists know all the compounds that do exist in nature.

On page 350, "The hope of transmuting the elements as of *lead, into gold* may be yet realized. All that is necessary is to knock the right number of electrons out of the atoms of some cheaper metal."

On page 108 appears a statement that does not agree with later definitions of weight in the text, "Since wood floats, it will have no weight when it is in water; it will have lost *all* its weight!" Not *all* wood will float in water. (Ebony.)

On page 23 is the statement, "Lead has no elasticity." All solids are elastic to some degree.

The authors use as an example of the effect of air pressure on animals, page 31, the act of pullng a fish from the lower depths of the ocean to the surface. The effect upon the fish is attributed to differences in *air* pressure.

Some of the questions proposed as topic studies are without answers if we rely only upon facts determined by scientific methods. For example: What is electricity? How do organisms originate? How did the earth originate? Will our fuel last forever? Why do apples drop from trees? How do we meet situations? Why must life be a struggle? Operationally these questions are without meaning as are several others asked by the authors.

An attempt to include some social aspects of science in the text has lead to the inclusion of these contradictory statements: On pages 426 and 427, "But there are millions of persons who cannot greatly benefit from the advances in industry, *because for reasons beyond their control, they are without jobs*. They have been dropped from the rolls of workers *simply because those who direct the factories and other productive organizations have no need for them, do not know how to use them profitably. Nobody seems responsible for this condition*, but it is disastrous to millions and cannot be satisfactory to the rest of us." The underlining has been done by the reviewer to show that if we accept the statements given, the responsibility is fixed by the authors on those who direct the factories and those who are responsible for the profit system. However, the authors deny that the responsibility can be ascribed to anyone!

The final chapter of the book presents an interesting discussion on the topics of scientific method and scientific knowledge. The placing of this material earlier in the book might have made it more functional for the pupils who are to use the text. These concepts should result from the study of science but unless an attempt is made to call the attention of the pupils to these concepts early in the course, they may complete their science course without having achieved many of these desirable methods of thinking.

HAROLD H. MC MULLEN

Biology for Life, a Workbook and Laboratory Manual for use with any Biology Textbook, by Harold U. Cope, Teacher of Biology, Union High School, Upper Sandusky, Ohio and Edwin Lincoln Moseley, Professor Emeritus of Biology, Bowling Green State University, Bowling Green, Ohio, edited by James R. Marks, Chairman, Science Department, Sharon Senior High School, Sharon, Pennsylvania. Paper. Pages viii+312. 26.7×21 cm. 1938. College Entrance Book Company, Inc., 104 Fifth Avenue, New York City. Price $0.72.

This book is obviously the product of experienced teachers of biology who have put much study and labor into its preparation. It is organized on the unit plan, the unit headings appearing as follows: I. Flowers, fruits, and Seeds. II. Our Six-Footed Folk—Friends and Enemies. III. The Green Plant Makes Food; Plant Classification. IV. The Classification of Animals. V. Relation of Foods to Health, Happiness, and Long Life. VI. Digestion—How Food Is Made Soluble. VII. The Blood—A Great Transportation System. VIII. The Nervous System—The Body Under Control. IX. The Quest for Health. X. Plant and Animal Wealth and Its Conservation. XI. The Laws of Heredity; The Improvement of all Life.

The arrangement of the book is attractive, each unit being introduced by a short "preview" with a drawing of a famous scientist who contributed to the branch of biology covered by such unit. Numerous line drawings, diagrams, and tables—which seem well adapted to the subject matter—are included as a part of the exercises. Each exercise, of which there are four to eight for each unit, is headed by a list of books and page references. At the end of each unit is a list of Questions for Further Study; Additional Questions for Students Desiring Extra Credit; Words for Study, Definition, and Spelling; Projects; Reports; and a Unit Test. In addition, according to the preface, a booklet of tests is provided free with each workbook.

Mechanically the book is pleasing, printed in clear type of good size, on an excellent grade of smooth white paper perfectly suited for pen and ink writing. The sheets (which are printed on both sides) are perforated and punched for removal and filing in loose leaf note books.

A rather careful examination has failed to disclose any errors of a serious nature. Some biologists will question the statement that "plants range in size from tiny organisms too small to be seen with the best microscopes . . ." and will doubt the wisdom of using—apparently for the sake of simplicity—the inaccurate expression "phylum vertebrates." The diagram of dominance in peas (p. 288) should be revised in the interest of clearness, and the misleading outline drawing of Paramecium (p. 92) should be replaced. These criticisms, however, are of minor importance as contrasted with the many excellent qualities of the book. This book is well worth the examination of teachers of high school biology.

EDWARD C. COLIN

The Evaluation of Higher Institutions, II, The Faculty, by Melvin E. Haggerty, Chicago: The University of Chicago Press, 1937. 218 pp.

This is the second of a series of monographs based on the investigation conducted for the Committee on Revision of Standards of the Commission on Higher Institutions of the North Central Association of Colleges and Secondary Schools. A composite criterion of educational excellence was established on the basis of ratings of experts, ranks on several tests, and ranks with respect to graduate work done by graduates of the fifty-six participating institutions. Various observable indices of faculty competence were studied to determine their degrees of relationship to the composite criterion of educational excellence. Coefficients of correlation were computed between all possible pairs of the variables studied, and the weights of the multiple regression equation which could be used in predicting the criterion were determined. However, for the practical purposes of accrediting, it is recommended that the following measures of faculty competence be used without weighting: (1) per cent of faculty holding an earned doctor's degree; (2) per cent of faculty holding an earned master's degree, but not holding a doctor's degree; (3) average number of months of graduate study; (4) average years of experience in college teaching and administration; (5) an index number of scholarly books and monographs published; (6) an index number of scholarly articles published; (7) an index number of membership in learned societies; (8) an index number of meetings attended in the last five years; (9) an index number of program appearances during the same period. These index numbers are obtained by dividing the total numbers concerned by the number of faculty members.

The newer method of accrediting no longer places reliance on fixed standards. Institutions are evaluated in terms of their comparative status with respect to traits which can be objectively and reliably measured. The "pattern map" has been devised to portray the status of a given institution with respect to the traits measured. Aspects of weakness and of strength are graphically represented. Since the reference scale on the pattern map is a percentile one, the status of each characteristic may be compared with the status of other characteristics and with the status of the characteristic in other higher institutions as shown by the reference percentile values. A facsimile of this pattern map is given in the appendix to this monograph.

MAX D. ENGELHART

Theory and Applications of Finite Groups, by G. A. Miller, Professor of Mathematics, University of Illinois; H. F. Blichfeldt, Professor of Mathematics, Stanford University; L. E. Dickson, Professor of Mathematics, University of Chicago. Reprint of 1916 Edition with corrections. Buckram. Pages ix+390. 15×22.5 cm. 1938. G. E. Stechert & Co. New York. Price $4.00.

The book is in three parts: Part I, by G. A. Miller, is a presentation of the essentials of the theory of substitution groups and abstract groups; Part II, by H. F. Blichfeldt, deals with linear groups; Part III, by L. E. Dickson, is a treatment of the Galois theory of equations and several geometrical problems which illustrate the field of applications of finite groups.

The reprinting of this standard work will be appreciated by all mathematicians who have any connection with either the theory or the applications of finite groups.

C. R. CASSITY

Landslides and Related Phenomena, by C. F. Stewart Sharpe, Soil Conservation Service, United States Department of Agriculture. Cloth. Pages xii+137. 15.5×23 cm. 1938. Columbia University Press, 2960 Broadway, New York, N. Y. Price $3.00.

The author of this book has made an extensive study both in the literature and in the field of all types of mass movements of soil and rock. He points out that such movements have not been sufficiently emphasized in the geology texts and very little on this subject can be found in the American libraries. The book gives many references to the works of others and suggests a new classification for landslides and related phenomena based on the kind of movement and its relative rate rather than upon kind of material deposited, size, water content, etc., as used in previous classifications. The book is well illustrated and will be of value to students of earth science and to practical workers in soil conservation, engineering, and geology.

G. W. W.

The Physical Treatises of Pascal, translated by I. H. B. and A. G. H. Spiers with introduction and notes by Frederick Barry. Associate Professor of the History of Science, Columbia University, New York City. Cloth. Pages xxviii+184. 15×23 cm. 1937. Columbia University Press, Columbia University, New York, N. Y. Price $3.25.

In general students of science get their classical science second-handed or even more remotely removed from the original sources. The original works are not read because they are not available or are not in convenient and attractive form. This book supplies a scientific classic that brings direct to the student of the history of science the method of thought of one of the great scientists of almost three centuries ago. The original work was published by F. Perier the year after Pascal's death. Perier's preface to the volume gives interesting incidents in the early life of Pascal. The book contains two complete treatises, "The Equilibrium of Liquids" and "The Weight of the Mass of the Air," and parts of other treatises and letters. The Appendices contain a part of Stevin's "Fourth Book of Statics," his "Fifth Book of Statics," Galileo's "Remarks on Nature's Abhorrence of a Vacuum" and Torricelli's "Letters on the Pressure of the Atmosphere."

G. W. W.

How to Teach, by Claude C. Crawford, Ph.D., Professor of Education, University of Southern California, Los Angeles, California. Southern California School Book Depository, 3636 Beverly Boulevard, Los Angeles, California. 1938. Cloth. 511 pp. $2.50.

This book impresses the reviewer as not being of the usual run of books on educational topics. This is expressed in the words of the author where he says, "I have been writing to the collegiate crowd instead of to the professors."

The subject matter of this book may be roughly divided into five parts. The first part is concerned with the mechanics of classroom procedure; the second part with the proper motivation and preparation of lesson assignments; the third part with the objectives sought in teaching; the fourth part with the methods and aids to teaching; and the fifth part with the results attained and their proper evaluation.

One outstanding feature of the book is the plan, consistently followed, of placing several suggestive activities at the beginning of each chapter.

Both students and experienced teachers will find these activities very helpful if time is taken to think them through.

The book is written in a style easily understood by young teachers. The references are useful and practical and there is a wealth of illustrative material that cannot fail to be interesting and helpful to beginning teachers.

The author emphasizes the fact that while the proper preparation of lesson material is important it is more important that there be an adequate appreciation of the ends to be attained by teaching. As a final word of admonition to the aspiring teachers the author points out the necessity for professional growth.

It is to be hoped that we may have more of this same kind of text in the educational field in the future so that some of the lag in education may be removed.

FRED H. OTTMAN

The Problems of Education, by Claude C. Crawford, Ph.D., Louis P. Thorpe, Ph.D., and Fay Adams, Ph.D., all of the University of Southern California. Cloth. Pages 239. 1938. Southern California School Book Depository, 3636 Beverly Boulevard, Los Angeles, California. $2.50.

In the words of the authors, "This course is an orientation; not a completion of the teacher-training program." For many years we have been hearing much about learning to do by doing, but this appears to be the first attempt to approach the general problem of education on the strictly pragmatic basis.

The book consists of fourteen chapters, each one of which is directly concerned with a specific problem in education. The authors have proceeded upon the assumption that the main purpose of education is to change the behavior of the learner so as to make it function more satisfactorily. The best way to accomplish this in education is to *do* something, not simply to get a background that may some day be useful, but rather to meet the challenges that arise in running the schools.

Emphasis is placed upon the need for selection from the total number of problems given, of as many problems as time will permit of consideration but under no circumstances should a problem be deliberately left unsolved. The problems are so important that they cannot be fully solved by the students, yet much will have been accomplished if the students have put forth earnest efforts in attempting their solution and thus have realized their nature and importance.

To the end that the problem may be better understood and the learner properly motivated each subdivision of a problem consists of a statement of *issues* in the form of questions; *activities* directed toward its solution; and *references* and *aids* in getting information. Particular mention should be made of the "Reserve Shelf" as an aid to more effective use of the library.

The book deserves the careful perusal of all instructors of teacher-training classes and will afford excellent material for class stimulation.

FRED H. OTTMAN

QUARTZ WOOL

To the growing varieties of "wool" derived from almost every conceivable substance from an animal's coat to minerals, German technicians now add quartz wool.

Quartz wool, Dr. Hecht of Hanau explains, is spun into finer threads than glass wool. It is extremely resistant to high temperatures, thus having a decided advantage over glass wool. It is also acid-resistant.

MICROSCOPY AND SPECTROGRAPHY OF GOLD ORES

In all of the countries of the world, the effect of the raising of the gold price from $20.67 an ounce to $35.00 has been to elevate submarginal and marginal gold-bearing material into ore and in all countries except the Rand, the world's greatest gold field, the output has increased. In the Rand, the policy is to mine lower grade ore and save the better ore for the future. Ths policy is also pursued in Ontario.

The United States has now reached the stage where extraordinary mechanical ingenuity has been developed to work the leaner, low-grade placer deposits, reaching its acme in the gold-digging dredges of California. The most productive mine in America, the Homestake, in the Black Hills, operates on low-grade ore ($3.00 to $4.00 a ton) but by the application of geology and mineralogy has raised its ore from $6.00 to $7.00 a ton, while with the new price of gold the ore is worth from $10.00 to $11.00 a ton.

Mineralogists are, as a consequence of this situation, being called on for microscopic studies of the identity, mode of occurrence, grain size of the metallic minerals, and to aid in the development of ore treatment methods. The spectrographer is also finding work to do in identifying minerals, determining the amount of the elements and detecting impurities.

The Problem of Sub-Microscopic Gold

The so-called "refractory" gold present in many ores has been the subject of much speculation, leading to various hypotheses as to its condition. Chief among these is the hypothesis of "solid solution," although the presence of colloidal gold has been a moot question. Both solid solutions and colloids are demonstrated to occur in nature. The concept of the solid solution is that the solute must be practically in a state of atomic division, the same being true for isomorphous substitution. The atomic radius of gold is given as approximately 0.000145 microns, or 0.000000145 millimeters, the lower limit of particle size that can exist without transmutation of the element. Above this size, therefore, gold must be considered as in the form of discrete, metallic particles. Between the atomic size and the lower limit of visibility at present possible with the microscope (about 0.1 microns), there lies a considerable range in which this metallic gold is submicroscopic. In this range, between 0.0006 microns and 0.0075 microns, lies the limited field in which the gold is regarded as colloidal in size. In milling practice, the nature of this gold may have some bearing on roasting.

The presence of sub-microscopic gold in some proportion is indicated by many ores in their behavior at the mill, but the most reliable method is to subject apparently barren sulphides to spectral analysis. For example the examination of auriferous pyrite from a mine failed to reveal a single grain of visible gold, yet every spectrographic analysis of samples drilled from polished surfaces proved the presence of the metal in considerable quantity.

Although the microscopic examination of mill products has been of far less value in connection with the study of gold ores than it has been in the study of base-metal ores, it is worthy of some mention. Such examinations give valuable information when methods of concentration are employed. The applications are usually to specific problems, and the value of the results depends chiefly upon the ingenuity and experience of the microscopist.

The future of America is in the hands of two men—the investigator and the interpreter.

—GLENN FRANK

ELECTRICAL EEL LIGHTS NEON LAMP, "TALKS" OVER LOUDSPEAKER

A 500-volt, 50-watt eel electrified an audience of scientists here by lighting a neon lamp, "talking" over a loudspeaker and otherwise putting on an electrifying display at the "command" of its exhibitors, Christopher W. Coates of the New York Aquarium and Richard T. Cox of New York University.

Brought to Washington for the opening session of the International Scientific Radio Union and the Institute of Radio Engineers' joint meeting, the eel, a young and healthy specimen of the electric eel which inhabits the shallow fresh waters of South America, was put through its paces while connected with a cathode ray oscillograph so that visitors could see for themselves the nature of the powerful electric charge it can generate.

It lighted a two-watt neon lamp when one of its demonstrators irritated it by putting his finger in its mouth. Connected to outside circuits by three metallic "garters" slipped around its body, the eel sent a modifying current through a loudspeaker system so that it could be "heard."

The eel demonstrated by the New York scientists is more than four feet long and weighs 10 pounds. "When excited," they declared, "the eel gives a train of direct current pulses, each lasting .002 seconds, running along the electric organs from head to tail at a speed of the order of one kilometer per second. On open circuit the discharge may reach a repeatable peak voltage of 500."

GLASS FABRIC AS ASPHALT ROAD REINFORCER

A patent has been granted to one of America's most prolific inventors for a method of reinforcing asphalt highways by the use of a spun glass fabric base.

Carleton Ellis of Montclair, N. J., who already has more than 700 patents to his credit and is second only to the late Thomas A. Edison in the number of patents granted him, received Patent No. 2,115,667 for his novel reinforcing method.

Strips of spun glass fabric or of fabric made from similar materials will increase resistance to wear and decrease maintenance cost of asphalt roads if included as a binder, Mr. Ellis declares in the specifications accompanying his patent. He proposes use of the glass fabric in the form of a criss-cross tape or as a cloth.

Cracking from cold and chipping at the edges of cracks are markedly reduced by incorporation of the flexible glass filler, he maintains. The fabric also serves to decrease the flow of soft asphalt on extremely warm days.

MEASURE THICKNESS OF COATING ON STEEL

A simple magnetic method of measuring the thickness of nonmagnetic coatings on steel has been worked out by Abner Brenner, a member of the staff of the National Bureau of Standards.

The method, which uses a scale to measure the force with which a permanent magnet is attracted to the object whose coating is being measured, depends on the decrease in attraction of a permanent magnet for steel when the two are separated by a nonmagnetic coating.

Measurements of commercial coatings of which the actual thicknesses were determined by standard methods yielded results that were accurate within 10% for most coatings.

Because nickel is less magnetic than steel, the thickness of nickel coatings on steel can be measured by this method, when suitable allowances are made.